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03

ATOMS AND MOLECULES

INTRODUCTION

INTRODUCTION

An atom is a tiny piece of matter that possesses the characteristics of an element. Some atoms exist independently of one another by producing ions and molecules. Molecules are produced when one or more atoms establish chemical bonds. It is the element's smallest component that shows its qualities. Molecules can be produced through chemical bonding between two or more atoms.

Atoms and molecules are responsible for forming tiny sand particles, gargantuan black holes and everything in between. The atom is the most fundamental unit of matter, making up everything that we see around us. It is extremely small, measuring in at less than 0.1 to 0.5 nanometres.

Law of Chemical Combination

Chemical Reactions

In a chemical reaction, two or more molecules interact to produce new compounds; they are called reactants, whereas the newly formed compounds are called products.

In a chemical reaction, a chemical change must occur, which is generally observed with physical changes like precipitation, heat production, colour change, etc.

Law of Conservation of Mass

According to the law of conservation of mass, matter can neither be created nor destroyed in a chemical reaction. It remains conserved.

The mass of reactants will be equal to the mass of products.

Example:

$$2\,H_2 + O_2 \longrightarrow 2\,H_2O$$

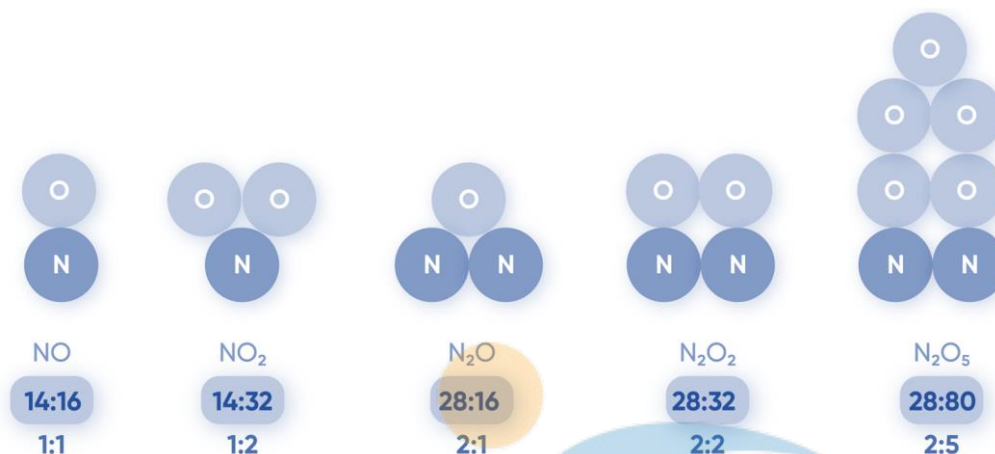Reactants   Reaction   Products
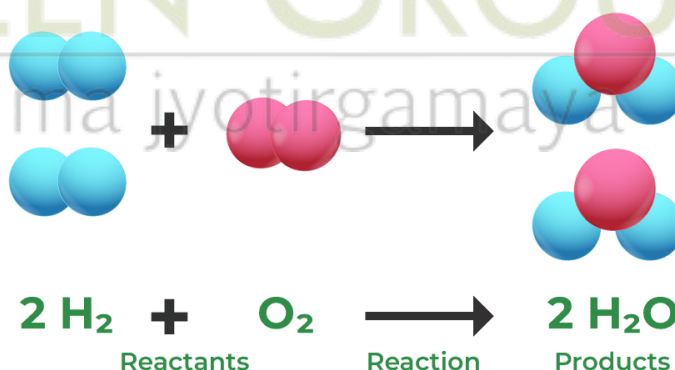
Law of Constant Proportions

A pure chemical compound containing the same elements combined together in a fixed proportion by mass is given by the law of definite proportions.

ATOMS AND MOLECULES

INTRODUCTION

NO	NO$_2$	N$_2$O	N$_2$O$_2$	N$_2$O$_5$
14:16	14:32	28:16	28:32	28:80
1:1	1:2	2:1	2:2	2:5

For e.g., If we take water from a river or from an ocean, both have oxygen and hydrogen in the same proportion.

The elements are present in chemical compounds in a predetermined mass ratio. The "Law of Constant Proportions" is this. This "Law of Constant Proportions" is also known as "Proust's law" or the "law of defined proportions." For instance, the oxygen and hydrogen content in pure water is always 1 : 8.

| 2 H$_2$	+	O$_2$	→	2 H$_2$O

4g

32g

1 : 8 (By Mass)
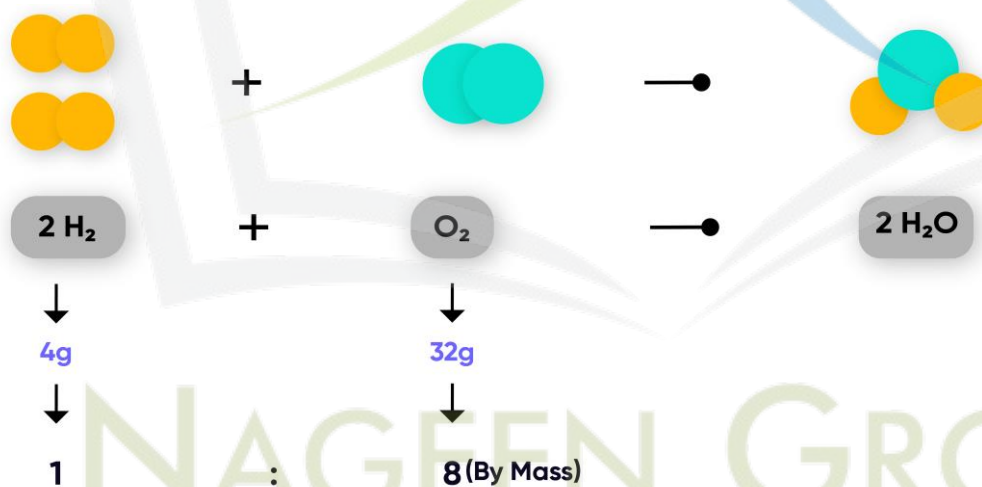
THE ATOMIC THEORY

Daltons atomic Theory

According to Dalton's Atomic Theory, atoms, which are indestructible and indivisible building blocks, make up all substances. Unlike other elements, which have atoms of different sizes and weights, an element's atoms have all the same size and mass.

Dalton proposed that the concept of atoms could be used to explain the laws of conservation of mass and definite proportions. He proposed that atoms, which he described as "solid, massy, hard, impenetrable, moving particle(s)", are the smallest, indivisible units of matter.

- The matter is made up of indivisible particles known as atoms.
- The properties of all the atoms of a given element are the same, including mass. This can also be stated as – all the atoms of an element have identical mass and chemical properties; atoms of different elements have different masses and chemical properties.
- Atoms of different elements combine in fixed ratios to form compounds.
- Atoms are neither created nor destroyed. The formation of new products (compounds) results from the rearrangement of existing atoms (reactants) in a chemical reaction.
- The relative number and kinds of atoms are constant in a given compound.

2 units
Two atoms
of hydrogen

16 units
One atom
of oxygen

18 units
One molecule
of water
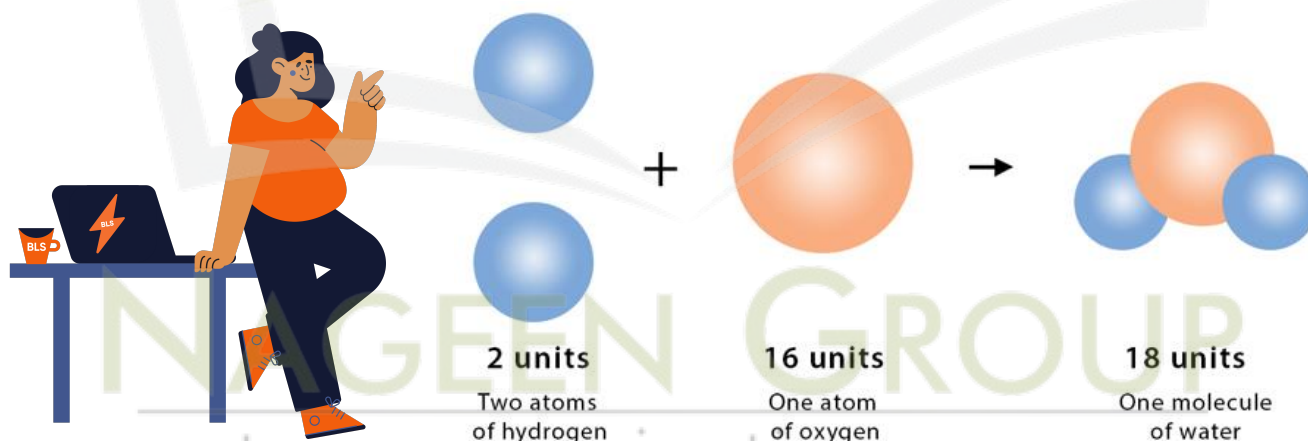
Atom

An atom is the defining structure of an element, which cannot be broken by any chemical means.

an atom is the smallest possible amount associated with a chemical element. For example, an atom of gold can be called as the smallest quantity of gold you can feasibly have. The word 'small' literally points out to nanoscopically tiny! An atom is thousands of times smaller than a human hair.

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ATOMS AND MOLECULES

THE ATOMIC THEORY
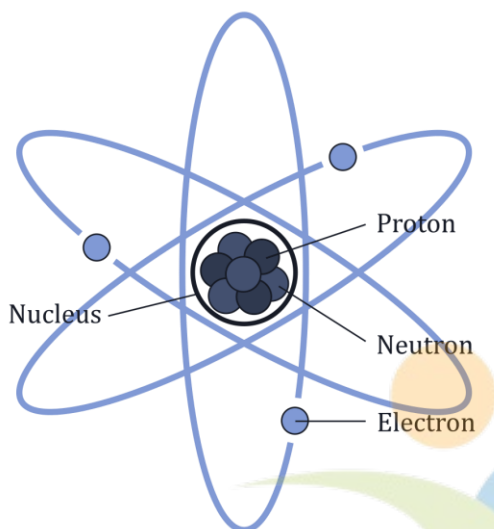
Hence, there is no chance you can see one without the help of a supremely powerful electron microscope. If you rip apart a variety of things, it would be revealed that all matter present around us is formed from different types of atoms. For example, living things are usually made from atoms hydrogen, carbon and oxygen.

Atomic Symbol

The atomic symbol has three parts:

- **The symbol X:** The usual element symbol
- **The atomic number A:** Equal to the number of protons
- **The mass number Z:** Equal to the total number of protons and neutrons in an element.

The symbols for representing an atom are generated from the first two letters of the element's name. The first letter is always in uppercase (capital letter) while the second letter is written in lowercase. Here are some examples –

Symbols for some elements as proposed by Dalton

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THE ATOMIC THEORY

Names and Symbols of some elements

Element	Symbol
Hydrogen	H
Helium	He
Lithium	Li
Beryllium	Be
Boron	B
Carbon	C
Nitrogen	N
Oxygen	O
Fluorine	F
Sodium	Na
Magnesium	Mg
Aluminium	Al
Phosphorous	P
Sulphur	S
Potassium	K
Calcium	Ca

Significance of the Symbols

A symbol gives information on the stoichiometric quantity of the element. e.g., "B" represents one atom of the element Boron. Likewise, "S" and "Mg" represent one atom of Sulphur and one atom of Magnesium respectively. As one atom is equal to 6.022×10^{-23} moles of particles. It can be interpreted that B has 6.022×10^{-23} moles of particles.

Atomic mass: In a balanced chemical reaction a particular symbol represents the definite mass of a particular element. Simply writing N means one atom of nitrogen which has an atomic mass of 14 u.

Compounds: In a complex reaction, it's tedious to write the full chemical names of the compound. e.g., Consider the chemical reaction shown below. Is it easy to write Water (product formed) or simply H_2O? With symbols right!

Identity: Every symbol is unique for every unique 118 elements. There should be no misunderstanding or misinterpretation while assigning or reading the chemical symbols. Ex- As explained above, "Ca, Cu, C, Cr, Cs, Cl" here even though they have the same first character, the second character is different. In sequence from left, they stand for Calcium, Copper, Carbon, Chromium, and Cesium.

Atomic Mass and Atomic Mass Unit
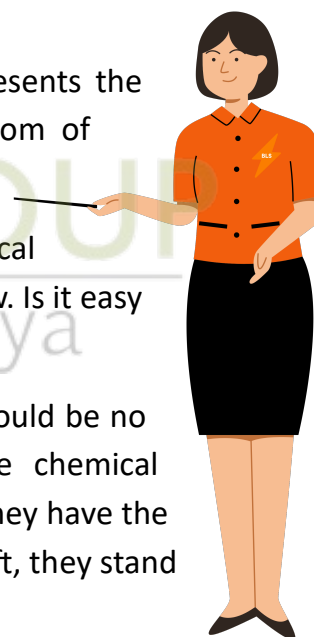
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THE ATOMIC THEORY

- Atomic mass is the total of the masses of the electrons, neutrons, and protons in an atom, or in a group of atoms, the average mass.
- The mass of an atomic particle is called the atomic mass.
- This is commonly expressed as per the international agreement in terms of a unified atomic mass unit (AMU).
- It can be best defined as 1/12 of the mass of a carbon-12 atom in its ground state.

Atomic Mass of an Element

Actual masses of the atoms of the elements are very very small.

For Example: The atom of hydrogen has a mass of 1.6727×10^{-27} kg. It is not convenient to use such small and complicated figures in our calculation, therefore, it was necessary to define atomic masses in such a way that we get simple figures for them.

Carbon-12 is that atom of carbon which has 6 protons and 6 neutrons in its nucleus so that so its mass number is 12.

carbon-12 atom has been assigned an atomic mass of exactly 12 atomic mass units. This means that a carbon-12 atom has been assigned an atomic mass of exactly 12u.

Atomic Mass unit = the mass of a carbon – 12 atoms

$$1u = \frac{\text{Mass of an carbon 12 atom}}{12}$$

One Atomic Unit is defined as exactly one-twelfth the mass of an atom of carbon-12.

Carbon-12 atom is taken to be the standard. The atomic masses of all other elements are determined by comparing the mass of their atom with the mass of a carbon-12 atom.

The atomic mass of an element is relative mass of its atom as compared with the mass of a carbon-12 atom taken as 12 units.

Relative atomic mass of an element

The relative atomic mass of an element is defined as the weight in grams of the number of atoms of the element contained in 12.00 g of carbon-12. To calculate the relative atomic mass of chlorine, the average mass of one atom of chlorine is found by considering 100 atoms of chlorine.

$$\text{Relative atomic mass} = \frac{\text{mass of 1 atom of the element}}{\frac{1}{2} \times \text{mass of 1 atom of } {}_6C^{12} \text{ isotope}}$$

Gram Atomic Mass of an Element

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THE ATOMIC THEORY

Gram atomic mass is the periodic table element's atomic weight in grams. The molar mass of an element is the mass of one mole in grams. The mass of one mole of an element is defined as its gram atomic mass.

It is calculated by taking an element's atomic weight from the periodic table and converting it to grams. Thus, when the mass of an element is expressed in grams then it is known as gram atomic mass. **For example,** the gram atomic mass of helium is 4g. Similarly, sodium (Na) has an atomic weight of 22.99u and a gram atomic mass of 22.99 grams. So one mole of sodium atoms weighs 22.99g. This implies that the quantity of the element of the given substance when weighs equal to its gram atomic mass is called one gram atom.

The gram atomic mass of a material is the amount of that substance in grams that is numerically equivalent to its atomic mass. If we wish to write a substance's gram atomic mass, we first write its atomic mass, then subtract the atomic mass unit u and add grams to the numerical value of the atomic mass. That is,

$$\text{Mass of the element (in g)} = \frac{\text{Number of gram atoms}}{\text{Atomic mass of the element (in g)}}$$

MOLECULE

Molecules are made up of one or more atoms that are held together by covalent bonds. Atoms can be represented as circle shapes with a nucleus in the center, surrounded by one or more concentric circles representing the shells in which the electrons surrounding the nucleus of the atom are located, and markings indicating the electron.

A molecule is the smallest unit of measurement that a substance can be divided into while still remaining the same substance. It is made up of two or more atoms that are chemically bonded together.

Molecules of Elements

A molecule is a collection of two or more chemically bound atoms, whether they are from the same element or another.

For example, when two hydrogen (H_2) atoms and one oxygen (O_2) atom interact, one water molecule is created.

Atomicity: the number of atoms in a molecule of an element is called its atomicity. For example, helium is monatomic, and oxygen is diatomic.

Molecule of single Element and their atomicity

Helium	Hydrogen	Oxygen	Chlorine	Sulfur
H	H_2	O_2	Cl	S_8
1	2	2	2	8

Ozone
O_3
3
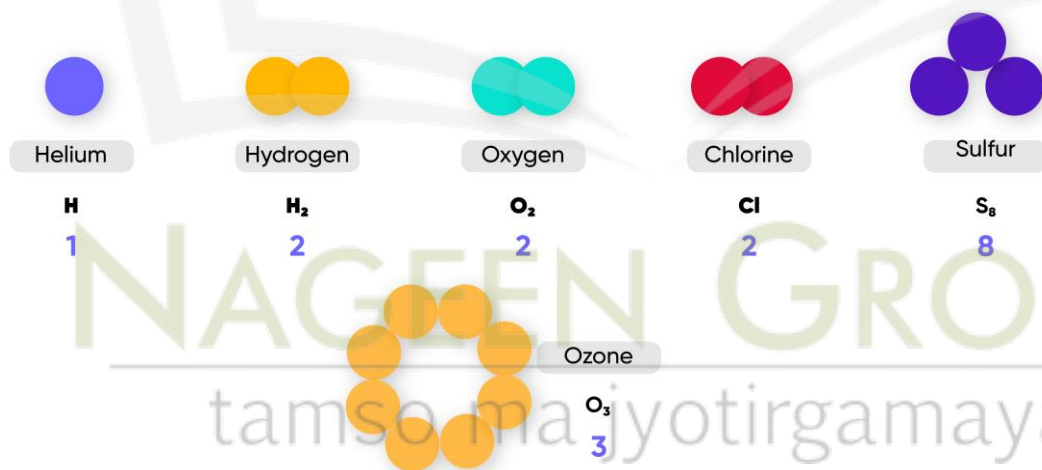
Monoatomic: When an element comprises a single atom. Example – all metals.

Diatomic: When an element comprises two atoms. Example – all gases.

Triatomic: When an element comprises of three atoms.

Tetra-atomic: When an element comprises of four atoms.

**Poly-atomic:** When an element comprises of more than two atoms.

03 ATOMS AND MOLECULES

MOLECULE

Here a few examples of atomicity of elements:

Atomicity of some Elements		
Name	Atomicity	Formula
Argon	Monoatomic	Ar
Helium	Monoatomic	He
Oxygen	Diatomic	O_2
Hydrogen	Diatomic	H_2
Nitrogen	Diatomic	N_2
Chlorine	Diatomic	Cl_2
Phosphorous	Tetra-atomic	P_4
Sulphur	Poly-atomic	S_8

Molecules of Compounds

Salts and molecular compounds are the two categories into which compounds can be divided. Covalent bonds hold the atoms together in molecular molecules. Ionic bonds hold it together in salts. Every compound is composed of one of these two types of bonds.

Actually, a compound is a kind of molecule. The atoms that join together must be distinct from one another for the substance to qualify as a compound. O_2, for instance, is a molecule, not a compound, due to its atomic connection with another oxygen atom. NaCl, however, is a compound since it is made up of two distinct atoms that are chemically bound together.

Water   Ammonia   Carbon dioxide   Methane
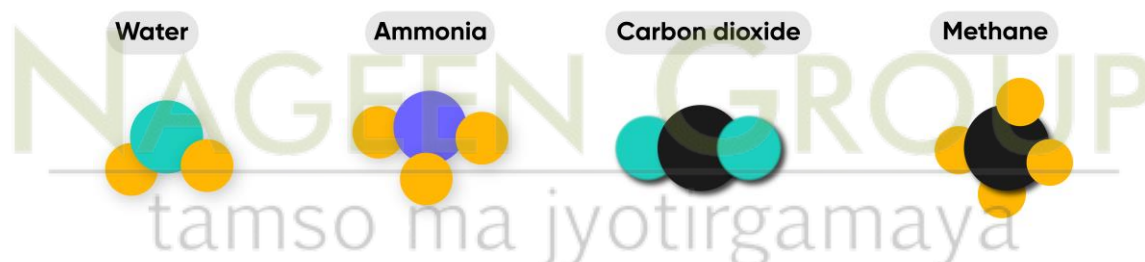
Molecular Formula

The molecular formula is the expression of the number of atoms of each element in one molecule of a compound.

The molecular formula definition is the formula showing the actual number of each atom in a molecule.

When the molar mass value is known, the Molecular Formula is calculated by the empirical formula.

$$n = \frac{\text{molar mass}}{\text{mass of the empirical formula}}$$

The molecular formula is often the same as an empirical formula or an exact multiple of it.

Example 1: Caffeine has the following composition: 49.48% of carbon, 5.19% of hydrogen, 16.48% of oxygen and 28.85% of nitrogen. The molecular weight is 194.19g/mol. Find out the molecular and empirical formula.

Solution:

Step 1 Multiply percent composition with the molecular weight.

Carbon – 194.19 × 0.4948 = 96.0852

Hydrogen – 194.19 × 0.0519 = 10.07846

Oxygen – 194.19 × 0.1648 = 32.0025

Nitrogen – 194.19 × 0.2885 = 56.0238

Step 2 Divide each value by the atomic weight.

Carbon: $\dfrac{96.0852}{12.011} = 7.9997$

Hydrogen: $\dfrac{10.07846}{1.008} = 9.998$

Oxygen: $\dfrac{32.0025}{15.9994} = 2.000$

Nitrogen: $\dfrac{56.0238}{14.0067} = 3.9997$

Step 3 Round off the values to closest whole number.

8: Carbon

10: Hydrogen

2: Oxygen

4: Nitrogen

Hence, the molecular formula is $C_8H_{10}N_4O_2$.

Step 4 Since 2 is the common factor among 8, 10, 4 and 2.

The empirical formula is $C_4H_5N_2O$.

CHEMICAL FORMULA

Ion

A charged atom or a group of charged atoms is called ions, It may be positively or negatively charged

Positively charged ion is called Cation.

Negatively charged ion is called Anion.

A group of atoms carrying a charge is known as a polyatomic ion.

For example- NH_4^+, NO_3^-

How is Ion formed?

We know that atom contains protons, neutrons and electrons.

Protons are Positively charged, Electrons are Negatively charged, Neutrons are Neutral.

In an atom, the number of protons is equal to the number of electrons, So the positive and negative charges are balanced out, Ions are formed when atoms lose or gain electrons.

Case 1: When an atom loses an electron,

The negative charge reduces. Thus it becomes positively charged - Cation, because;

The number of positively charged protons becomes more than negatively charged electrons.

Case 2: When atom gains an electron,

The negative charge increases.

Thus, it becomes negatively charged - Anion, because;

The number of negatively charged electrons becomes more than positively charged protons.

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CHEMICAL FORMULA
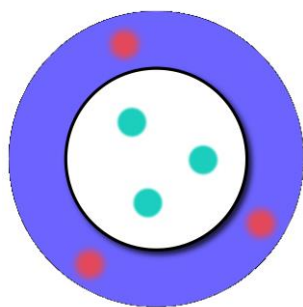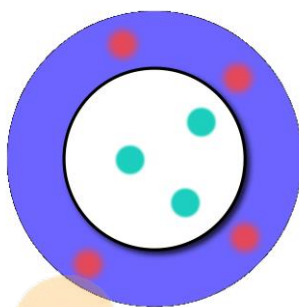
Cation	Anion
Positively charged ion is called Cation	Negatively charged ion is called anion
It is formed when atom loses electron (and hence become positively charged)	It is formed when atom gains electron and become positively charged
Example - Sodium Ion (Na +)	Example - Chloride Ion (Cl -)
Sodium (Na) has 11 protons and 11 electrons. Overall charge is 0	Chlorine (Cl) has 17 protons and 17 electrons. Overall charge is 0
When sodium loses 1 electron It has 11 protons and 10 electrons, Positive charge > Negative charge Thus, becomes Cation (Na +)	When chlorine gains 1 electron It has 17 protons and 18 electrons, Negative charge > Positive charge Thus, becomes Anion (Cl -)
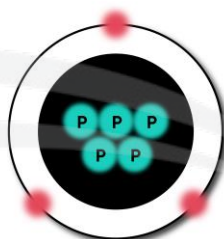
Cation
- ☑ Positively charged
- ☑ More protons than electrons
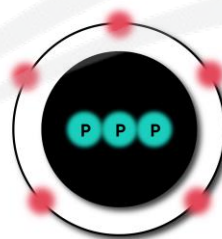
Anion
- ☑ Negatively charged
- ☑ More electrons than protons

Ionic Compounds: Chemical Formula

Each constituent element in a chemical formula is identified by its chemical symbol, along with the relative number of atoms that make up each element. These ratios are used in empirical equations to start with a key element and then assign atom counts for the remaining elements in the compound in relation to the key element.

- Ionic compounds are chemical compounds in which ions are held together by specialised bonds called ionic bonds.
- An Ionic compound always contains an equal amount of positive and negative charge.

- **For example:** In calcium chloride, the ionic bond is formed by oppositely charged calcium and chloride ions.
- The calcium atom loses 2 electrons and attains the electronic configuration of the nearest noble gas (Ar). By doing so, it gains a net charge of +2.

Calcium atom
Ca - 2, 8, 8, 2

Calcium ion
Ca²⁺ - 2, 8, 8
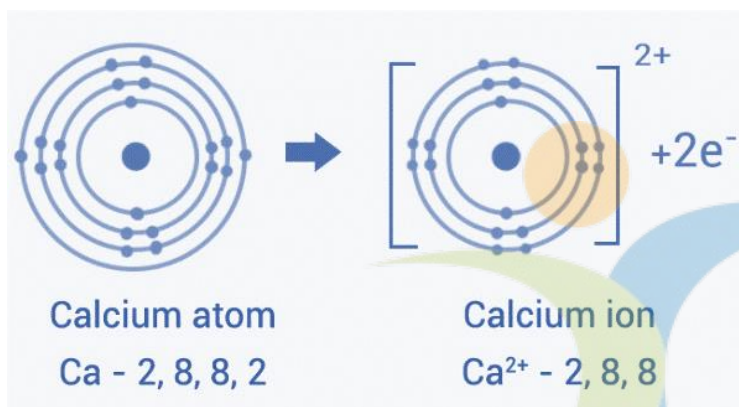
The two chlorine atoms take one electron each, thus gaining a charge of -1 (each) and attain the electronic configuration of the nearest noble gas (Ar).

Chlorine atom
Cl - 2, 8, 7

Chloride ion
Cl⁻ - 2, 8, 8
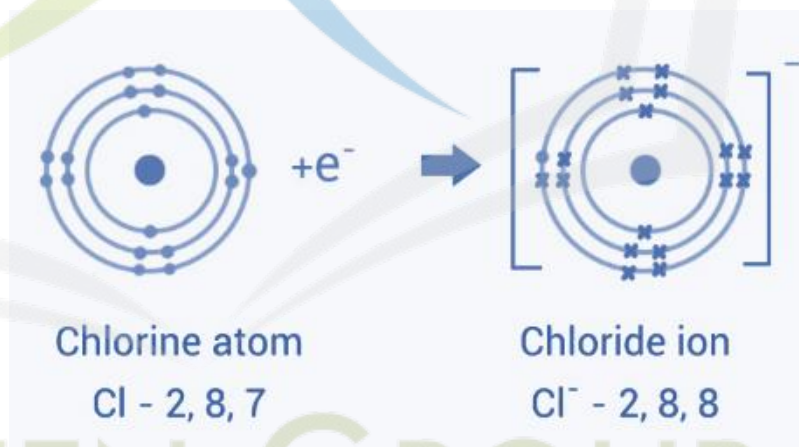
Valency

The combining capacity of an atom is known as its valency. The number of bonds that an atom can form as part of a compound is expressed by the valency of the element.

How is valency used to write the formula of compounds?

What is a chemical formula?

- A chemical formula is a symbolic representation of a chemical compound.
- It tells us about the type and number of atoms present in the compound.
- For example, the chemical formula of salt is NaCl.

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CHEMICAL FORMULA

- It tells us that NaCl is composed of one atom of Sodium (Na) and 1 atom of Chlorine (Cl)

Rules to follow while writing a chemical Formula:

- The valences on the ion must balance.
- When a compound contains a metal and nonmetal.
- Name/Symbol of Metal is written first.

Example 1:

We write Calcium Oxide (CaO) and not Oxide Calcium

This is because Calcium (Ca) is a metal and Oxygen (O) is a non metal

Example 2:

We write Sodium Chloride (NaCl) and not Chloride Sodium

Molecular mass

The molecular mass of an element is defined as the sum of all the masses of the elements present inside the molecule. e.g., the molecular mass of water, in which there are two hydrogen atoms and one oxygen atom present, is 18 (i.e., 2 + 16). Also called its molecular weight.

Unit of Molecular Mass

SI unit of Molecular Mass or Molecular Weight is an atomic mass unit which in short is called a.m.u. It is sometimes represented by u which represents unified mass.

Calculation of Molecular Mass

Molecular mass is predicted by multiplying the number of atoms with the atomic mass of an element in the molecule and then adding the masses of all the elements in the molecule.

Make sure to analyse the chemical formula to determine the number of atoms of each element in the compound.

Multiply the number of atoms present in the compound by the atomic weight of each element.

Add up all the mass and assign its unit as grams/mole.
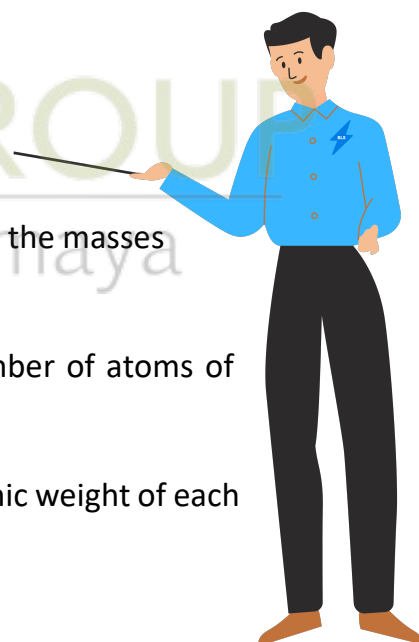
Example 1: Determine the Molar mass of CO_2.

Solution:

First Calculate the number of each atom and assign their atomic weight individually.

The number of carbon atoms × its atomic mass: 1 × 12 = 12

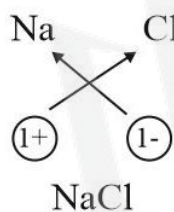The number of oxygen atoms × its atomic mass: 2 × 16 = 32

Then add the values i.e., 12 + 32 = 44
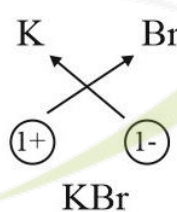
Therefore, the molar mass of CO_2 is 44 g/mol.
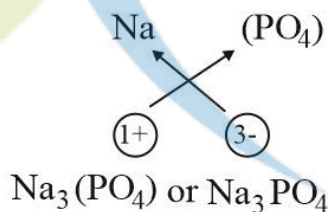
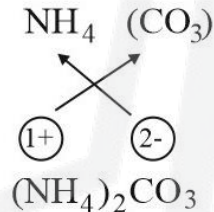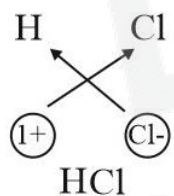**Name of compounds and their formula making**

Sodium chloride

$$Na \quad Cl$$
$$(1+) \quad (1-)$$
$$NaCl$$

Potassium bromide

$$K \quad Br$$
$$(1+) \quad (1-)$$
$$KBr$$

Sodium phosphate

$$Na \quad (PO_4)$$
$$(1+) \quad (3-)$$
$$Na_3(PO_4) \text{ or } Na_3PO_4$$

Ammonium carbonate

$$NH_4 \quad (CO_3)$$
$$(1+) \quad (2-)$$
$$(NH_4)_2CO_3$$

Hydrogen chloride

$$H \quad Cl$$
$$(1+) \quad (Cl-)$$
$$HCl$$

Barium oxide

$$Ba \quad O$$
$$(2+) \quad (2-)$$
$$Ba_2O_2 \text{ or } BaO$$

Calcium hydroxide

$$Ca \quad (OH)$$
$$(2+) \quad (1-)$$
$$Ca(OH)_2$$

Potassium dichromate

$$K \quad (Cr_2O_7)$$
$$(1+) \quad (2+)$$
$$K_2(Cr_2O_7) \text{ or } K_2Cr_2O_7$$
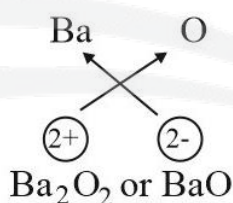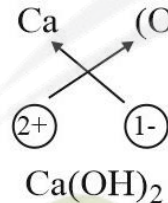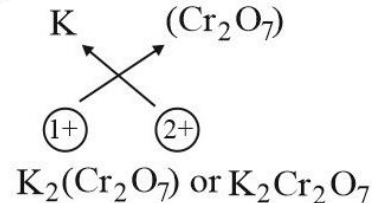
Formula Unit Mass

The sum of atomic masses of all atoms in a formula unit of a compound is called its formula unit mass. The formula unit mass is used in the case of substances that constitute ions. For example, the formula unit mass of Sodium Chloride (NaCl) can be calculated as: (1 × 23) + (1 × 35.5) = 58.5u

Formula unit mass of ZnO

= 1 × atomic mass of Zn + 1 × atomic mass of O

= 1 × 65 u + 1 × 16 u = 81 u

Formula unit mass of Na_2O

ATOMS AND MOLECULES

CHEMICAL FORMULA

= 2 × atomic mass of Na + 1 × atomic mass of O

= 2 × 23 u + 1 × 16 u = 62 u

Formula unit mass of K_2CO_3

= 2 × atomic mass of K + 1 × atomic mass of C + 3 × atomic mass of O

= 2 × 39 u + 1 × 12 u + 3 × 16 u

= 78 u + 12 u + 48 u = 138 u

Mole Concept

How do we interpret a chemical equation?

Suppose a chemical equation is: $2C + O_2 = 2CO_2$

We say that two molecules of carbon combine with one molecule of oxygen to form two molecules of carbon dioxide.

We can also say that 24u of Carbon molecules combine with 32u of oxygen molecules to form 56u of carbon dioxide molecules.

Therefore, we can characterise the quantity of a substance by its mass or by its number of molecules.

A chemical equation directly indicates the number of molecules participating in the reaction. Thus, it is convenient for us to refer to the number of substances in a chemical reaction as numbers of molecules or atoms.
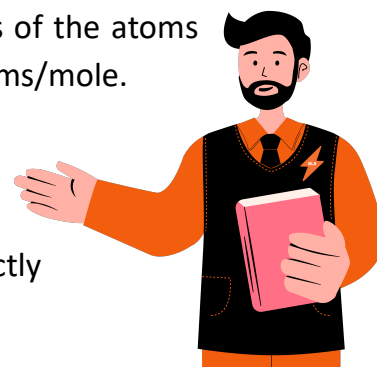
Moler Mass & Moles

Molar Mass

A substance is something which has mass and occupies space. The molar mass/molecular weight is actually the sum of the total mass in grams of the atoms present to make up a molecule per mole. The unit of molar mass is grams/mole.

$$\text{Molar mass} = \frac{\text{mass}}{\text{mole}} = \text{g/mol}$$

The mass of one atom of carbon-12 the atomic mass of carbon-12 is exactly 12 atomic mass units.

ATOMS AND MOLECULES

CHEMICAL FORMULA

The mass of one mole of carbon-12 atoms is exactly 12 grams; its molar mass is exactly 12 grams per mole.

Moles

the mole is a fundamental (SI) unit used to measure the amount of substance. This quantity is sometimes referred to as the chemical amount.

A substance is something that has mass and occupies space. The molar mass/molecular weight is actually the sum of the total mass in grams of the atoms present to make up a molecule per mole. The unit of molar mass is grams/mole.

Atoms and Molecules

DPP-01

[Topic: Atoms, Symbols of elements, Atomic mass, Molecules of elements and compounds, Ions, Writing chemical formula, Molecular mass, Formula unit mass]

Very Short Answer Type Questions

1. What is meant by the term chemical formula?

2. How many atoms are present in a:
   (i) H_2S molecule
   (ii) PO_4^{3-} ion?

3. Name the unit in which atomic radius is measured.

4. Define molecular mass.

5. What is the formula unit mass?

6. Name the element used as a standard for atomic mass unit.

7. In what form does oxygen occur in nature?

8. In what form noble gases exist in nature?

9. What is the difference between 2H and H_2 ?

10. Calculate formula unit mass of $Mg(NO_3)_2$. $(Mg = 24u, N = 14u, O = 16u)$

11. Define the atomic mass unit.

12. Why is it not possible to see an atom with naked eyes?

13. Define atomicity.

14. How many atoms are present in one molecule of ozone?

15. Give an example of:
    (a) Triatomic,
    (b) Polyatomic molecules of elements.

16. Define law of constant proportion.

17. What is the ratio between mass of carbon and oxygen in CO_2 ? $(C = 12u\ O = 16u)$

18. Name the anion and cation present in molecule of magnesium oxide.

19. An element ' X ' has valency 3. Write the formula of its oxide.

20. Write the names of compounds $(a) Ag_2O$ (b) CuS

21. Write the symbol for following elements ((a) Iron (b) Potassium

22. Give the difference between a cation and an anion?

23. Write the names of the following compounds:
    (a) $Al_2(SO_4)_3$
    (b) NH_4OH

24. Which of the following statements is not true about an atom?
    (a) Atoms are not able to exist independently.
    (b) Atoms are the basic units from which molecules and ions are formed.
    (c) Atoms are always neutral in nature.
    (d) Atoms aggregate in large numbers to form the matter that we can see, feel or touch.

25. The chemical symbol for nitrogen gas is:
    (a) Ni
    (b) N_2
    (c) N^+
    (d) N

26. The chemical symbol for sodium is:
    (a) So
    (b) Sd
    (c) NA
    (d) Na

27. Which of the following represents a correct chemical formula? Name it.
    (a) CaCl
    (b) $BiPO_4$
    (c) $NaSO_4$
    (d) NaS

28. The oxide of 'Al' has a chemical formula Al_2O_3. State the valency of Al.

29. What is the formula of ammonium chloride?

Short Answer Type Questions-I

30. Write down the formulae of:
    (a) sodium oxide
    (b) aluminium chloride
    (c) sodium sulphide
    (d) magnesium hydroxide

31. (a) Calculate the relative molecular mass of water (H_2O).
    (b) Calculate the relative molecular mass of HNO_3.

32. Calculate the formula unit mass of $CaCl_2$ -

33. What is atomicity? Explain with two examples.

34. Calculate relative molecular mass of H_2 and NH_3 [Atomic mass of H $= 1u$, N $= 14u$]

35. Give the names of the elements present in the following compounds:
    (a) Quicklime
    (b) Hydrogen bromide

(c) Baking powder

(d) Potassium sulphate

36. As per law of definite proportions, carbon and oxygen combine in the ratio of $3 : 8$. Compute the mass of oxygen that would be required to react completely with 6 g of carbon.

37. Find the formula unit mass of (a) NaHCO$_3$ (b) Na$_2$CO$_3$

38. Select the element that is (a) ductile, (b) conductor of electricity, (c) a constituent of water, (d) non-metal, liquid at room temperature.

39. Hydrogen and Oxygen combine in the ratio $1 : 8$ by mass for water. What mass of oxygen gas would be required to completely react with 4 g of hydrogen gas?

40. Classify the following compounds as diatomic, triatomic and polyatomic molecule:

$$HCl, H_2, H_2O, NH_3$$
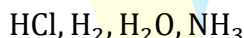
41. Write the cations and anions present (if any) in the following compounds:
    (a) CH$_3$COONa
    (b) NaCl
    (c) H$_2$
    (d) NH$_4$NO$_3$

42. Which of the following symbols of elements are incorrect? Give their correct symbols.
    (a) Cobalt- CO
    (b) Carbon-C
    (c) Aluminium - Al
    (d) Helium- He
    (e) Sodium -So

Short Answer Type Questions-II

43. Write down the names of compounds represented by the following formula:
    (a) Al$_2$(SO$_4$)$_3$
    (b) CaCl$_2$
    (c) K$_2$SO$_4$
    (d) KNO$_3$
    (e) CaCO$_3$.

44. Calculate the formula unit masses of ZnO, Na$_2$O, K$_2$CO$_3$. [Atomic mass of Zn $= 65u$, O $= 16u$Na $= 23u$, K $= 39u$, C $= 12u$]

45. What is the difference between homoatomic and heteroatomic molecules? Illustrate with the help of four examples each?

46. A 0.24 g sample of compound of oxygen and boron was found by analysis to contain 0.096 g of boron and 0.144 g of oxygen. Calculate the percentage composition of the compound by weight.

47. When 3.0 g of carbon is burnt in 8.0 g oxygen, 11.0 g of carbon dioxide is produced. What mass of carbon dioxide will be formed when 3.0 g of carbon is burnt in 50.0 g of oxygen? Which law of chemical combination will govern your answer?

48. What are polyatomic ions? Give examples.

49. Write the chemical formulae of the following.
    (a) Magnesium chloride
    (b) Calcium oxide
    (c) Copper nitrate
    (d) Aluminium chloride
    (e) Calcium carbonate

50. The percentage of three elements, calcium, carbon and oxygen in a sample is given as $Ca = 40\%\, C = 12\%\, O = 48\%$
    If law of constant proportion is true, what weights of these elements will be present in 1.5 g of another sample of calcium carbonate? [Atomic mass of $Ca = 40u$, $C = 12u$, $O = 16u$]

51. How will you prove law of conservation of mass experimentally?

52. (a) When 5 g of calcium is burnt in 25 g of oxygen then 7 g of calcium oxide is produced. What mass of calcium oxide will be produced when 5 g of calcium is burnt in 20 g of oxygen? Which law of chemical combination will govern your answer? State the law.
    (b) Write the chemical formula of calcium oxide.

53. Write the molecular formulae for the following compounds:
    (a) Copper(II) bromide
    (b) Aluminium(III) nitrate
    (c) Calcium(II) phosphate
    (d) Iron(III) sulphide
    (e) Mercury(II) chloride
    (f) Magnesium(II) acetate

54. Give the formulae of the compounds formed from the following sets of elements:
    (a) Calcium and fluorine
    (b) Hydrogen and sulphur
    (c) Nitrogen and hydrogen
    (d) Carbon and chlorine
    (e) Sodium and oxygen
    (f) Carbon and oxygen

Long Answer Type Questions

55. Calculate the molecular masses of $H_2, O_2, Cl_2, CO_2, CH_4, C_2H_6, C_2H_4, NH_3, CH_3OH$. [Atomic Mass of $H = 1u, O = 16u, Cl = 35.5u, C = 12u, N = 14u$]

56. Write the molecular formulae of all the compounds that can be formed by the combination of following ions:

    $$Cu^{2+}, Na^+, Fe^{3+}, Cl, SO_4^{2-}, PO_4^{3-}$$

57. Define the following terms:
    (a) Atom
    (b) Molecule
    (c) Avogadro's number

(d) Valency
(e) Molar mass

Atoms and Molecules

DPP-02

[Topic: Dalton Atomic Theory, Laws of Chemical Composition]

Very Short Answer Type Questions

1. Which postulate of Dalton's atomic theory is the result of the law of conservation of mass?

2. Which postulate of Dalton's atomic theory can explain the law of definite proportions?

3. What is the full form of IUPAC?

4. Name the scientist who gave the atomic theory of matter.

5. What are building blocks of matter?

6. Name two laws of chemical combination.

7. State the law of conservation of mass.

8. State the law of constant proportions.

Short Answer Type Questions

9. In a reaction, 5.3 g of sodium carbonate reacted with 6 g of ethanoic acid. The products were 2.2 g of carbon dioxide, 0.9 g water and 8.2 g of sodium ethanoate. Show that these observations are in agreement with the law of conservation of mass.
   Sodium carbonate + ethanoic acid $\rightarrow$ sodium ethanoate + carbon dioxide + water.

10. Hydrogen and oxygen combine in the ratio of $1:8$ by mass to form water. What mass of oxygen gas would be required to react completely with 3 g of hydrogen gas?

11. Write the main postulates of Dalton's atomic theory.

Atoms and Molecules

DPP-03

[Topic: Mole Concept]

Very Short Answer Type Questions

1. How many atoms are there in 1 gram of hydrogen?

2. What is meant by Avagadro's constant?

Short Answer Type Questions-I

3. If one mole of carbon atoms weighs 12 grams, what is the mass (in gram) of 1 atom of carbon? [Atomic mass of $C = 12u$]

4. What is the mass of:
   (a) 0.2 mole of oxygen atoms?
   (b) 0.5 mole of water molecules? [Atomic mass of $O = 16u, H = 1u$]

5. Calculate the number of molecules of sulphur (S_8) present in 16 g of solid sulphur. [Atomic mass of $S = 32u$]

6. (a) Calculate the number of moles in 34 g of NH_3 [$N = 14u, H = 1u$]
   (b) Calculate number of molecule in 8 g dioxygen gas [$O = 16u$]

7. Calculate mass of 1 molecule of oxygen gas.

8. The mass of single atom of an element is 2.65×10^{-23} g. Calculate its atomic mass.

9. Which of the following correctly represents 360 g of water?
   (i) 2 moles of H_2O
   (ii) 20 moles of water
   (iii) 6.022×10^{23} molecules of water
   (iv) 1.2044×10^{25} molecules of water
   (a) (i)
   (b) (i) and (iv)
   (c) (ii) and (iii)
   (d) (ii) and (iv)

10. Which of the following would weigh the highest?
    (a) 0.2 mole of sucrose $(C_{12}H_{22}O_{11})$
    (b) 2 moles of CO_2
    (c) 2 moles of $CaCO_3$
    (d) 10 moles of H_2O

11. Which of the following has maximum number of atoms?
    (a) 18 g of H_2O
    (b) 18 g of O_2
    (c) 18 g of CO_2
    (d) 18 g of CH_4

12. Which of the following contains maximum number of molecules?
    (a) 1 g of CO_2
    (b) lg of N_2
    (c) lg of H_2
    (d) 1 g of CH_4

Short Answer Type Questions-II

13. Calculate the number of moles for the following:
    (i) 52 g of He (finding mole from mass)
    (ii) 12.044×10^{23} number of He atoms (finding mole from number of particles).
    [Atomic mass of He $= 4u$]

14. Calculate the mass of the following:
    (i) 0.5 mole of N_2 gas (mass from mole of molecule)
    (ii) 0.5 mole of N atoms (mass from mole of atom)
    (iii) 3.011×10^{23} number of N atoms (mass from number)
    (iv) 6.022×10^{23} number of N_2 molecules (mass from number)
    [Atomic mass of N $= 14u$]

15. Calculate the number of particles in each of the following:
    (i) 46 g of Na atoms (number of atoms from mass)
    (ii) 8 g of O_2 molecules (number of molecules from mass)
    (iii) 0.1 mole of carbon atoms (number from given moles)
    [Atomic mass of Na $= 23u, O = 16u, C = 12u$]

16. Which has more number of atoms, 100 grams of sodium or 100grams of iron (given, atomic mass of Na $= 23u,$ Fe $= 56u$?

17. What is the mass of:
    (a) 1 mole of nitrogen atoms
    (b) 4 mole of aluminium atoms (Atomic mass of aluminium $= 27$)
    (c) 10 moles of sodium sulphite (Na_2SO_3)
    [Atomic mass of N $= 14u,$ Al $= 27u,$ Na $= 23u,$ S $= 32u, O = 16u$]

18. Convert into moles.
    (a) 12 g of oxygen gas
    (b) 20 g of water
    (c) 22 g of carbon dioxide. [Atomic Mass of O $= 16u,$ H $= 1u, C = 12u$]

19. Calculate number of molecules of phosphorus (P_4) present in 248 g of solid phosphorus. [Given atomic mass: P $= 31u,$ $N_A = 6.022 \times 10^{23}$ per mole]

20. The atomic mass of calcium is $40u$. What will be the total number of calcium atoms in $0.4u$ of calcium?

21. 3.42 g of sucrose $(C_{12}H_{22}O_{11})$ is dissolved in 18 g of H_2O in a beaker. Calculate the total number of oxygen atoms in the solution.

22. Compute the difference in masses of 10^3 mole each of Mg atoms and Mg^{2+} ions (Mass of electron $= 9.1 \times 10^{-31}$ kg)

23. A sample of (C_2H_6) has the same mass as 1.5×10^{20} molecules of CH_4. How many C_2H_6 molecule does the sample of gas contain?

Long Answer Type Questions

24. Calculate the molar mass of the following substances:
    (a) Ethyne, C_2H_2
    (b) Sulphur molecule, S_8
    (c) Phosphorus molecule, P_4 (Atomic mass of phosphorus $= 31$)
    (d) Hydrochloric acid, HCl
    (e) Nitric acid, HNO_3
    [Atomic mass of $C = 12u$, $H = 1u$, $S = 32u$, $Cl = 35.5u$, $N = 14u$, $O = 16u$, $P = 31u$]

25. Calculate the number of aluminium ions present in 0.051 g of aluminium oxide.
    (Hint: The mass of an ion is the same as that of an atom of the same element. Atomic mass of $Al = 27u$) [Atomic mass of $Al = 27u$, $O = 16u$]

26. (a) Calculate the number of oxygen atoms in 0.1 mole of $Na_2CO_3 \cdot 10H_2O$
    (b) If one mole of sulphur weighs 32 grams, what is the mass in grams of 1 atom of sulphur?
    (c) Identity the correct formula of ammonium sulphate?

$$(NH_4)(SO_4)_3, (NH_4)_2SO_4, NH_4(SO_4)_2$$

03
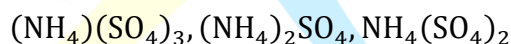
ATOMS AND MOLECULES

INTRODUCTION

(Practice Sheet)

1   **What is the fundamental unit of matter?**

    A. Molecule   **B.** Atom

    C. Element   **D.** Compound

2   **What is formed when two or more atoms establish chemical bonds?**

    A. Elements   **B.** Molecules

    C. Compounds   **D.** Ions

3   **What is the size range of an atom?**

    A. 1 to 5 nanometres   **B.** 0.5 to 1 nanometre

    C. 0.1 to 0.5 nanometres   **D.** 5 to 10 nanometres

4   **What is the law that states matter cannot be created nor destroyed in a chemical reaction?**

    A. Law of Constant Proportions   **B.** Law of Conservation of Energy

    C. Law of Chemical Combination   **D.** Law of Conservation of Mass

5   **What are the compounds formed in a chemical reaction called?**

    A. Atoms   **B.** Reactants

    C. Elements   **D.** Products

6   Define the Law of Constant Proportions.

7   Write the chemical formulas for the following compounds.
Sodium Chloride, 2. Aluminium Chloride, 3. Calcium Carbonate, 4. Magnesium Hydroxide.

8   Write the valencies for the following atoms.
1. Oxygen, 2. Calcium, 3. Nitrogen, 4. Phosphorous, 5. Chlorine

9   What is the size range of an atom, and why is it considered the most fundamental unit of matter?

10 Explain the Law of Conservation of Mass and its significance in chemical reactions.

03 ATOMS AND MOLECULES

THE ATOMIC THEORY

(Practice Sheet)
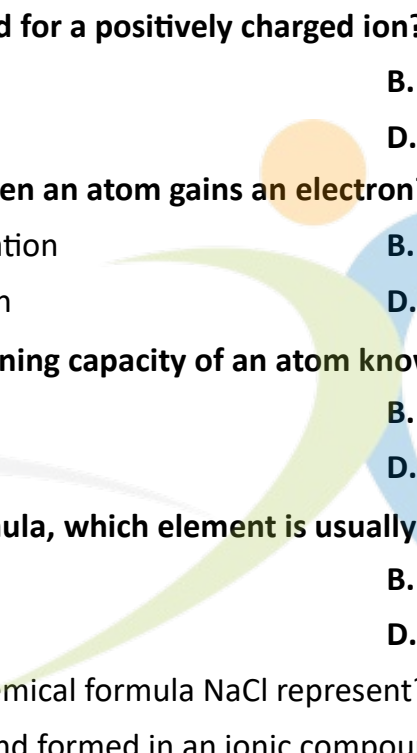
1 **What did Dalton propose in his Atomic Theory regarding the nature of atoms?**

  A. Atoms are continuously divisible.

  B. Atoms have varying sizes within the same element.

  C. Atoms are indestructible and indivisible.

  D. Atoms can be created in chemical reactions.

2 **According to Dalton, what is the key factor that determines the identity of an element?**

  A. Number of neutrons

  B. Atomic mass

  C. Number of electrons

  D. Number of protons

3 **What information does the atomic symbol of an element provide?**

  A. Number of electrons

  B. Atomic mass

  C. Identity of the element

  D. Number of protons

4 **What is the significance of the symbols representing elements?**

  A. Represents the number of moles

  B. Indicates the mass of the element

  C. Provides information on stoichiometric quantity

  D. Represents the number of neutrons

5 **What is the relative atomic mass of an element?**

  A. The weight of one mole of the element

  B. The mass of one atom of the element

  C. The mass of an atom relative to carbon-12

  D. The average mass of isotopes of the element

6 Why is the atomic mass of carbon-12 taken as the standard for defining atomic masses of other elements?

7 Define the gram atomic mass of an element and provide an example.

8 How is the gram atomic mass of an element calculated?

9 What did Dalton propose about the nature of atoms in his Atomic Theory?

10 Define an atom and explain why atoms are not visible to the naked eye.

03

ATOMS AND MOLECULES

MOLECULE

(Practice Sheet)

1 **What holds atoms together in a molecule?**

    A. Ionic bonds   **B.** Covalent bonds

    C. Metallic bonds   **D.** Hydrogen bonds

2 **What is the smallest unit of measurement that a substance can be divided into while still remaining the same substance?**

    A. Atom   **B.** Element

    C. Molecule   **D.** Compound

3 **Which of the following elements is diatomic?**

    A. Argon   **B.** Helium

    C. Oxygen   **D.** Sulphur

4 **How many atoms does a tetra-atomic element comprise?**

    A. 1   **B.** 2

    C. 3   **D.** 4

5 **In which type of bond are atoms held together in salts?**

    A. Covalent bonds   **B.** Metallic bonds

    C. Ionic bonds   **D.** Hydrogen bonds

6 What is the molecular formula of a compound?

7 Which type of formula shows the actual number of each atom in a molecule?

8 What is a molecule, and how is it formed?

9 Explain the difference between salts and molecular compounds in terms of their bonds.

10 Differentiate between covalent bonds and ionic bonds in compounds.

03

ATOMS AND MOLECULES

CHEMICAL FORMULA

(Practice Sheet)

1 **What is a charged atom or group of charged atoms called?**

    A. Neutron   **B.** Electron

    C. Ion   **D.** Proton

2 **Which term is used for a positively charged ion?**

    A. Neutron   **B.** Anion

    C. Cation   **D.** Electron

3 **What happens when an atom gains an electron?**

    A. It becomes a cation   **B.** It becomes an anion

    C. It loses a proton   **D.** It becomes neutral

4 **What is the combining capacity of an atom known as?**

    A. Charge   **B.** Atomic mass

    C. Valency   **D.** Ionization energy

5 **In a chemical formula, which element is usually written first?**

    A. Nonmetal   **B.** Metal

    C. Anion   **D.** Cation

6 What does the chemical formula NaCl represent?

7 How is an ionic bond formed in an ionic compound?

8 What is the unit of molecular mass?

9 What is valency?

10 Define formula unit mass and explain its significance in ionic compounds.

Chapter 3
Atoms and Molecules

Multiple Choice Questions

1.Which of the following correctly represents 360 g of water?
(i) 2 moles of H20
(ii) 20 moles of water
(iii) 6.022 × 1023 molecules of water
(iv) 1.2044×1025 molecules of water

(a) (i)
(b) (i) and (iv)
(c) (ii) and (iii)
(d) (ii) and (iv)

Soln:
Answer is (d) (ii) and (iv)

Explanation:

Number of moles = Mass of water
                  Molar mass of water

Number of moles = 360g
                  12g/mol

Number of moles = 20

Number of molecules = 20 x 6.022 x 10^{23} = 1.2044 x 10^{25} molecules of water

Thus, option (d) is correct.

2. Which of the following statements is not true about an atom?
(a) Atoms are not able to exist independently
(b) Atoms are the basic units from which molecules and ions are formed
(c) Atoms are always neutral in nature
d) Atoms aggregate in large numbers to form the matter that we can see, feel or touch

Soln:

Answer is d) Atoms aggregate in large numbers to form the matter that we can see, feel or touch

Explanation:

Atoms aggregate in large numbers to form the matter But we cannot see the matter with our naked eyes.

3. The chemical symbol for nitrogen gas is
(a) Ni
(b) N2
(c) N+
(d) N

Soln:

Answer is (b) N2

Explanation:
Chemical formula of Nitrogen is N but Nitrogen exist in molecule of two ions hence chemical symbol of Nitrogen is written as N2.

4. The chemical symbol for sodium is
(a) So
(b) Sd
(c) NA
(d) Na

Soln:

Answer is (d) Na

Explanation:

Sodium word is derived from Latin word Natrium hence the chemical name of sodium is Na.

5. Which of the following would weigh the highest?
(a) 0.2 mole of sucrose (C12 H22 O11)
(b) 2 moles of CO2
(c) 2 moles of CaCO3
(d) 10 moles of H2O

Soln:
Answer is (c) 2 moles of CaCO3

Explanation:

Weight of a sample in grant = Number of moles x Molar mass
(a) 0.2 moles of Ci2H220,, = 0.2 x 342 = 68.4 g
(b) 2 moles of CO is 2 x 44 is. 88 g
(c) 2 moles of CaCO? 2 x IIMI - 200 g (4) 10 moles of I-120 = 10 x 18 - 1St g
Hence, option (c) is correct.

6. Which of the following has maximum number of atoms?
(a) 18g of H2O
(b) 18g of O2
(c) 18g of CO2
 (d) 18g of CH4

Soln:
Answer is (d) 18g of CH4

Explanation:

Number of atoms =   Mass of substance × Number of atoms in the molecule/ Molar mass × NA

(a) 18 g of water = 18 x3/18 ×NA = 3 NA

(b) 18 g of oxygen = 18 x2 /32 × NA = 1.12 NA

(c) 18 g of CO_2 = 18 x3/44 × NA = 1.23 NA

(d) 18 g of CH_4 = 18 x5 /16 × NA = 5.63 NA

Note: NA = 6.023×10^{23}

7. Which of the following contains maximum number of molecules?

(a) 1g CO2

(b) 1g N2

(c) 1g H2

(d) 1g CH4

Soln:

Answer is (c) 1g H2

Note: NA = 6.023×10^{23}

Explanation:

1 g of H_2 = ½ x NA = 0.5 NA = 0.5 × 6.022 × 1023 = 3.011 × 1023

8. Mass of one atom of oxygen is
(a) 23 16 g 6.023 10 ×
(b) 23 32 g 6.023 10 ×
(c) 23 1 g 6.023 10 ×
 (d) 8u

Soln:

Answer is (a) 23 16 g 6.023 10 ×

Explanation:

Mass of one atom of oxygen = Atomic mass/NA = 16/6.023 × 1023 g

Note: NA = 6.023×10^{23}

9. 3.42 g of sucrose are dissolved in 18g of water in a beaker. The number of oxygen atoms in the solution are
(a) 6.68×10^{23} (b) 6.09×10^{22} (c) 6.022×10^{23} (d) 6.022×10^{21}

Soln:

Answer is (a) 6.68×10^{23}

Explanation:

1 mol of sucrose (C12H22O11) contains = 11× NA atoms of oxygen, where NA = 6.023×10^{23}

0.01 mol of sucrose (C12 H22 O11) contains = 0.01 × 11 × NA atoms of oxygen

= 0.11× NA atoms of oxygen

= 18 g/(1x2+ 16)gmol-1

=18 g /18 gmol-1

= 1mol

1mol of water (H2O) contains 1×NA atom of oxygen

Total number of oxygen atoms =

Number of oxygen atoms from sucrose + Number of oxygen atoms from water

= 0.11 NA + 1.0 NA = 1.11NA

Number of oxygen atoms in solution = 1.11 × Avogadro's number

= 1.11 × 6.022 ×10"23 = 6.68×10^{23}

10. A change in the physical state can be brought about
(a) only when energy is given to the system
(b) only when energy is taken out from the system
(c) when energy is either given to, or taken out from the system
 (d) without any energy change

Soln:

Answer is (c) when energy is either given to, or taken out from the system

Short Answer Questions

11. Which of the following represents a correct chemical formula? Name it.
(a) CaCl
(b) BiPO4
 (c) NaSO4
(d) NaS

Soln:

Answer is (b) BiPO4, Its name is Bismuth Phosphate

Explanation:

Bismuth phosphate is right because Both ions are trivalent Bismuth phosphate(Bi^{3+}- Trivalent anion. anion is an ion that is negatively charged).

12. Write the molecular formulae for the following compounds

(a) Copper (II) bromide
(b) Aluminium (III) nitrate
(c) Calcium (II) phosphate
(d) Iron (III) sulphide
(e) Mercury (II) chloride
(f) Magnesium (II) acetate

Soln:

Answers are

(a) Copper (II) bromide- $CuBr_2$

(b) Aluminium (III) nitrate = $Al(NO_3)_3$

(c) Calcium (II) phosphate - $Ca_3(PO_4)_2$

(d) Iron (III) sulphide - Fe_2S_3

(e) Mercury (II) chloride - $HgCl_2$

(f) Magnesium (II) acetate- $Mg(CH_3COO)_2$

13. Write the molecular formulae of all the compounds that can be formed by the combination of following ions Cu^{2+}, Na^+, Fe^{3+}, Cl^- SO_4^{-2} , PO_4^{-3}

Soln:
Answers are
$CuCl_2$/ $CuSO_4$/ $Cu_3 (PO_4)_2$
$NaCl$/ Na_2SO^4/ $Na_3 PO^4$
$FeCl_3$/ $Fe_2(SO_4)_3$ / $FePO_4$

14. Write the cations and anions present (if any) in the following compounds
(a) CH_3COONa
b) $NaCl$
(c) H_2
(d) NH_4NO_3

Soln:

a) In CH_3COONa-CH_3COO is anion and Na is cation.

b) In NaCl-Cl anion Na is cation

c) In H_2 both the ions are cations as they share electrovalent bond between them

d) In NH_4NO_3- NO_3 is anion NH_4 is cation

15. Give the formulae of the compounds formed from the following sets of elements
(a) Calcium and fluorine
(b) Hydrogen and sulphur
(c) Nitrogen and hydrogen
(d) Carbon and chlorine
(e) Sodium and oxygen
(f) Carbon and oxygen

Soln:

(b) Hydrogen and sulphur- H_2S- Hydrogen Sulphide

(c) Nitrogen and hydrogen- NH_3- Ammonia

(d) Carbon and chlorine – CCl_4- Carbon Tetra chloride

(e) Sodium and oxygen – Na_2O-Sodium Oxide

(f) Carbon and oxygen- CO_2 ; CO- Carbon-di-oxide; Carbon Monoxide

16. Which of the following symbols of elements are incorrect? Give their correct symbols

(a) Cobalt CO

(b) Carbon c

(c) Aluminium AL

(d) Helium He

(e) Sodium So

Soln:

Cobalt CO is wrong, correct symbol is Co

Carbon c is wrong, correct symbol is C

Alluminium AL is wrong, correct symbol is Al

Helium He is the right symbol

Sodium So is wrong, correct symbol is Na

17. Give the chemical formulae for the following compounds and compute the ratio by mass of the combining elements in each one of them. (You may use appendix-III).

(a) Ammonia

 (b) Carbon monoxide

(c) Hydrogen chloride

(d) Aluminium fluoride

(e) Magnesium sulphide

Soln:

Sl. No.	Compounds	Chemical formula	Ratio by mass of the combining elements
(a)	Ammonia	NH_3	N:H=14:3
(b)	Carbon monoxide	CO	C:O= 12:16=3:4
(c)	Aluminium fluoride	HCl	H:Cl= 1:35.5
(d)	Aluminium fluoride	AlF_3	Al:F=27:57=9:19
(e)	Magnesium sulphide	MgS	Mg:S= 24:32=3:4

18. State the number of atoms present in each of the following chemical species

(a) $CO3^{-2}$

 (b) $PO4^{-3}$

(c) P_2O^5

(d) CO

Soln:

(a) $CO3^{-2}$- **1+3=4**

 (b) $PO4^{-3}$ -**1+4=5**

(c) P_2O^5 – **2+5=7**

(d) CO – **1+1=2**

19. What is the fraction of the mass of water due to neutrons?

Soln:

 Mass of 1 mole of a substance is equal to its relative atomic or molecular mass in grams.

Mass of one mole (Avogadro Number) of neutrons =1g

Mass of one neutron = 1/ Avogadro number(NA) g

Mass of one molecule of water = Molar mass / NA = 18/ NA g

The molar mass of water is
18.015 g/mol. This was
calculated by multiplying the atomic weight of hydrogen (1.008) by two and adding the result to the weight for one oxygen (15.999)

Mass of one molecule of water = Molar mass / NA = 18/ NA g

Avogadro number(NA) =6.022 x 1023mol⁻1

There are 8 neutrons in one atom of oxygen

Number of neutrons in oxygen= number of oxygen - Atomic number of oxygen

Oxygen's atomic weight= 15.9994
increases with an increase in temperature.
Therefore the mass is 16

Therefore number of neutrons= 16 - 8 = 8

Mass of one neutron = 1/ Avogadro number(NA) g

Mass of 8 neutrons = 8/ Avogadro number(NA) g

Fraction of mass of water due to neutrons = 8/18 g

20. Does the solubility of a substance change with temperature? Explain with the help of an example.

Soln:

Solubility is the ability of a solute to get dissolved in 100g solvent. Solubility of a given solute to dissolve in specific solvent depends on the temperature. With Increase in temperature solubility of liquids and solids increase. In the same way solubility of gases decreases with increase in temperature.

Ex: Sugar dissolves faster in hot water than in cold water.

21. Classify each of the following on the basis of their atomicity.
(a) F2
 (b) NO2
(c) N2O
(d) C2H6
(e) P4
(f) H2O2
(g) P4O10
 (H) O3
 (i) HCl
 (j) CH4
(k) He
(l) Ag

Soln:

a) Monoatomic are inert gases that do not combine and exist as monoatomic gases
b) Diatomic- (a) 2- diatomic- NO_2 = 1+ 2 = 3., HCl = 1+ 1 = 2
c) Triatomic-N_2O = 2 + 1 = 3., NO_2 = 1+ 2 = 3, O_3 = 3
d) Tetraatomic- H_2O_2 = 2 + 2 = 4, P_4O_{10} = 4 + 10 = 14, P_4 = 4, CH_4 = 1+ 4= 5
e) Octa atomic- C_2H_6 = 2 + 6 = 8
f) Polyatomic.

22. You are provided with a fine white coloured powder which is either sugar or salt. How would you identify it without tasting?

To examine if the fine white coloured powder is sugar pr salt we can conduct two experiments.

Soln:

1. Heating: Upon heating sugar melts to liquid form because sucrose has a decomposition point and melting point at temperatures between 190 to 192 degrees Celsius. This will turn sugar to light brown colour. Upon heat further sugar gets charred to black colour.

Salt has a melting point of 841 degrees Celsius and 1545.8 degrees Fahrenheit. If we don't heat it to that point nothing change is observed.

2. Electric conductivity:

If we dissolve the given substance in water we can check for electric conductivity to check whether the substance is sugar or salt. If it is salt it conducts electricity. Because salt (NaCl) has positive sodium ions and negative chloride ions hence salt conducts electricity. But sugar don't conduct electricity as sugar has only positive ions.

23. Calculate the number of moles of magnesium present in a magnesium ribbon weighing 12 g. Molar atomic mass of magnesium is 24g mol–1.

Soln:

Number of moles = $\dfrac{weight}{atomic\ weight}$

= $\dfrac{12}{24}$ = 0.5 moles

Long Answer Questions

24. Verify by calculating that (a) 5 moles of CO2 and 5 moles of H2O do not have the same mass. (b) 240 g of calcium and 240 g magnesium elements have a mole ratio of 3:5.

Soln:

(a) Molar mass of CO_2 =12 + 2 x 16= 12 + 32 = 44 g mol^{-1}

5 moles of CO_2 have mass = 44 x 5 = 220 g

Similarly, molar mass of H_2O = 2x 1 + 16 = 18 g mol^{-1}

5 moles of H2O have mass =18
x 5 = 90 g

It is verified that 5 moles of CO_2 and 5 moles of H_2O are not same.

   (b) Number of moles = w/ atomic weight

        Atomic weight of Ca= 40 amu

        Number of moles in 240g Ca metal 240/ 40 = 6

        Number of moles in 240g of Mg metal 240/ 24 = 10

        Atomic weight of Mg = 24amu

        Ratio 6:10

25. Find the ratio by mass of the combining elements in the following compounds. (You may use Appendix-III) (a) CaCO3 (d) C2H5OH (b) MgCl2 (e) NH3 (c) H2SO4 (f) Ca(OH)2

Soln:

a) CaCO3
Ca: C : O × 3
40 : 12 : 16 × 3
40: 12 : 48
10 : 3 : 12

(b) MgCl2
Mg : Cl × 2
24: 35.5 × 2
24: 71

(c) H2SO4
H x 2 : S : O × 4
2: 32 : 16 × 4
2 : 32 : 64
1: 16: 32

(d) C2H5OH
C × 2 : H × 6 : O
12 × 2 : 1 × 6 : 16
24 : 6 : 16
12 : 3 : 8

(e) NH3

N : H × 3

14 : 1 × 3

14: 3

(f) Ca(OH)2

Ca : O × 2 : H × 2

40 : 16 × 2 : 1 × 2

40 : 32 : 2

20 : 16 : 1

26. Calcium chloride when dissolved in water dissociates into its ions according to the following equation. CaCl2 (aq) → Ca2+ (aq) + 2Cl– (aq) Calculate the number of ions obtained from CaCl2 when 222 g of it is dissolved in water.

Soln:

1 mole of calcium chloride = 111g

Therefore 222g of CaCl2 is equivalent to 2 moles of CaCl2

Since 1 formula unit CaCl2 gives 3 ions,

therefore, 1 mol of CaCl2 will give 3 moles of ions 2 moles of CaCl2 would give 3×2=6 moles of ions.

No. of ions = No. of moles of ions × Avogadro number

$= 6 \times 6.022 \times 10^{23}$

$= 36.132 \times 10^{23}$

$= 3.6132 \times 10^{24}$ ions

27. The difference in the mass of 100 moles each of sodium atoms and sodium ions is 5.48002 g. Compute the mass of an electron.

Soln:

Sodium atom and ion differ by one electron. For 100 moles each of sodium atoms and ions there would be a difference of 100 moles of electrons.

Mass of 100 moles of electrons= 5.48002 g

Mass of 1 mole of electron = 5.48002 / 100 g

Mass of one electron = $5.48002 / 100 \times 6.022 \times 10^{23}$

$= 9.1 \times 10^{28}$ g

$= 9.1 \times 10^{-31}$ kg

28. Cinnabar (HgS) is a prominent ore of mercury. How many grams of mercury are present in 225 g of pure HgS? Molar mass of Hg and S are 200.6 g mol–1 and 32 g mol–1 respectively.

Soln:
Molar mass of HgS = The molar mass of Hg + the molar mass of S
= 200.6 + 32 = 232.6 g mol^{-1}
1molecule of HgS contains 1 atom of Hg
232.6 g of HgS contains 200.6 g of Hg
Therefore, Mass of Hg in 225 g of HgS = $\dfrac{200.6}{232.6}$ X 225 = 194.04g

29. The mass of one steel screw is 4.11g. Find the mass of one mole of these steel screws. Compare this value with the mass of the Earth (5.98 × 10^{24}kg). Which one of the two is heavier and by how many times?

Soln:
One mole of screws weigh = 2.475 ×10^{24}g
= 2.475×10^{21} kg

Mass of the Earth / Mass of 1 mole of screws = $\dfrac{5.98 \times 10^{24} \text{ kg}}{2.475 \times 10^{21}}$

= 2.4 ×10
Mass of earth is 2.4×10^3 times the mass of screws
The earth is 2400 times heavier than one mole of screws

30. A sample of Vitamin C is known to contain 2.58 ×1024 oxygen atoms. How many moles of oxygen atoms are present in the sample?

Soln:

We know,
1 mole = 6.022 x 10^{23}
The number of moles= $\dfrac{\text{Given number of particles}}{\text{Avogadro Number}}$

n= $\dfrac{2.58 \text{x} 10^{24}}{6.022 \text{x} 10^{23}}$

n= 4.28 mol

31. Raunak took 5 moles of carbon atoms in a container and Krish also took 5 moles of sodium atoms in another container of same weight.
(a) Whose container is heavier?
(b) Whose container has more number of atoms?

Soln:

a) Mass of sodium atoms carried by Krish = (5 ×23) g = 115 g

Atomic weight of Na = 23

While mass of carbon atom carried by Raunak = (5 ×12) g = 60g

b) Thus, Krish's container has more number of atoms

32. Fill in the missing data in the Table 3.1

Species property	H_2O	CO_2	Na atom	$MgCl_2$
No of Moles	2	-	-	0.5
No of particles	-	3.011×10^{23}	-	0
Mass	36g	-	115g	0

Soln:

Species property	H_2O	CO_2	Na atom	$MgCl_2$
No of Moles	2	0.5	5	0.5
No of particles	12.044×10^{24}	3.011×10^{23}	3.011×10^{23}	3.011×10^{23}
Mass	36g	22g	115g	47.5g

33. The visible universe is estimated to contain 1022 stars. How many moles of stars are present in the visible universe?

Soln:

Number of moles of stars $= \dfrac{10^{22}}{6.023 \times 10^{23}}$

$= 0.0166$ moles

34. What is the SI prefix for each of the following multiples and submultiples of a unit?
(a) 103
(b) 10–1
 (c) 10–2
(d) 10–6
(e) 10–9
(f) 10–12

Soln:

a) 103 = 1000= kilo

(b) 10–1 =1/10= 0.1= deci

(c) 10–2 =1/100 = 0.01= centi

(d) 10–6 = 0.000 001= micro

(e) 10–9 =0.000 000 001 = nano

(f) 10–12=0.000 000 000 001 = pico

35. Express each of the following in kilograms
(a) 5.84×10-3 mg
(b) 58.34 g
(c) 0.584g
 (d) 5.873×10-21g

Soln:

(a) 5.84×10^{-3} mg = 5.84×10^{-9} kg

(b) 58.34 g =5.834×10^{-2} kg

(c) 0.584g =5.84×10^{-4} kg

(d) 5.873×10^{-21}g=5.873×10^{-24} kg

36. Compute the difference in masses of 103 moles each of magnesium atoms and magnesium ions.
(Mass of an electron = 9.1×10–31 kg)

Soln:

Mg^{2+} ion and Mg atom differ by two electrons.
103 moles of Mg^{2+} and Mg atoms would differ by
$10^3 \times 2$ moles of electrons
Mass of 2×10^3 moles of electrons = $2 \times 103 \times 6.023 \times 1023 \times 9.1 \times 10^{-31}$ kg
 $2 \times 6.022 \times 9.1 \times 10^{-5}$kg
 109.6004×10^{-5} kg
1.096×10^{-3}kg

37. Which has more number of atoms? 100g of N2 or 100 g of NH3

Soln:

No. of moles of atoms = weight / atomic weight.
For N$_2$
100 gms of N$_2$ = 100/2 x 14 moles = 100/28 moles
Number of molecules = 100 / 28 x 6.022 x 10^{23}
Molar mass of N$_2$ = 2 x molar mass of monoatomic N
Molar mass of N$_2$ = 2 x 14.0067 = 28 moles.
Number of molecules = 100/28 x 6.022 x 10^{23}
No. of atoms = 2 x 100/28 x 6.022 x 10^{23} = 43.01 x 10^{23}
For NH$_3$

100 gm of NH_3 = 100/17 moles
Number of molecules = 100/17 x
6.022 x 10^{23} molecules
No. of atoms in NH_3 = (1 + 3) = 4 x 100/17 x 6.022 x 10^{23} =
141.69 x 10^{23} atoms.
Therefore, NH_3 has more atoms than N_2.

38. Compute the number of ions present in 5.85 g of sodium chloride.

Soln:

58.5 g NaCl contains 6.023 x 10^{23} molecules
therefore 58.5 g NaCl contains 12.046 x 10^{23} ions.
Hence, 5.85 g NaCl contains $\dfrac{5.85 \times 12.046 \times 10^{23}}{58.5}$

= 1.2046 x 10^{23} ions

39. A gold sample contains 90% of gold and the rest copper. How many atoms of gold are present in one gram of this sample of gold?

Soln:

One gram of gold sample will contain $\dfrac{90}{100}$ = =0.9g of gold

Number of moles of gold=$\dfrac{\text{mass of gold}}{\text{atomic mass of gold}}$

= $\dfrac{0.9}{197}$

= 0.0046

One mole of gold contains NA atoms = 6.022×10^3

Therefore, 0.0046 mole of gold will contain= 0.0046 × 6.022
=2.77×10^{21}

40. What are ionic and molecular compounds? Give examples.

Soln:

While forming some compounds, atoms gain or lose electrons, and form electrically charged particles called ions.
Compounds that are formed by the attraction of cations and anions are called as ionic compounds.
Ex : 2Na + Cl2 → 2Na+ Cl- → 2NaCl (sodium chloride- common salt.)
Sodium is a group 1 metal, thus forms a +1 charged cation. Chlorine is a non-metal, and has the ability to form a -1 charged anion.

Compounds formed due to bonding of uncharged ions are called as molecular compounds and the bonding between them is called covalent bonding. Molecular compounds are formed by sharing of electrons between the two atoms and the elements are held together by covalent bonds.

Ex: $2C + O_2 \rightarrow 2CO$ (Carbon monoxide)

41. Compute the difference in masses of one mole each of aluminium atoms and one mole of its ions. (Mass of an electron is 9.1×10^{-28} g). Which one is heavier?

Soln:

Mass of one mole of Aluminium atom = {13 × mass of each electron + 13 × mass of each proton + 14 × mass of each neutron} × Avogadro's constant.
We know, if atoms convert into ions, only transfer of electrons takes place, in Al^{+3} ion, Aluminium atom loss three electrons,
So,
Mass of Al^{+3} ={10× mass of each electron +13 × mass of each proton + 14 × mass of each neutron} Avogadro's constant
Now,
You see mass of aluminium atom is greater than aluminium ion by 3 electrons
Difference in mass =Mass of Aluminium atom -mass of aluminium ion
= 3 × mass of each electron x Avogadro's constant .
= $3 \times 9.1 \times 10^{-28}$x 6.023 x 10^{23}
=27.3 x 10^{-28} x 6.023 x 10^{23} g
=164.4 x 10^{-5} g
= 1.644 x 10^{-3} g
= 0.0016 g

42. A silver ornament of mass 'm' gram is polished with gold equivalent to 1% of the mass of silver. Compute the ratio of the number of atoms of gold and silver in the ornament.

Soln:
Mass of silver = m g
Mass of gold = m /100g
Number of atoms of silver = Mass/ Atomic mass X NA
= m /108NA Number of atoms of gold
= m/ 100 X197
Ratio of number of atoms of gold to silver = Au : Ag
= m/ 100 X 197 X NA : m/ 108 NA
= 108 : 100×197
= 108 : 19700 =
1 : 182.41

43. A sample of ethane ($C2H6$) gas has the same mass as 1.5×10^{20} molecules of methane ($CH4$). How many $C2H6$ molecules does the sample of gas contain?

Soln:

6.02 x 10^{23} molecules of methane = 1 mole
Hence 1.5 x 10^{20} molecules of methane = (1.5 x 10^{20} x 1) ÷ (6.02 x 10^{23}) moles
= 2.49 x 10^{-4} moles
Molar mass of Methane (CH_4) = 12 + 1x4 = 16 g

Mass of methane = molar mass x no. of moles = 16 x 2.49 x 10^{-4} = 3.984 x 10^{-3} g (This is the same mass as Ethane)

Ethane (C2H6) = 12x2 + 1x6 = 30

If 30 g of Ethane has 6.02 x 10^{23} molecules

So 3.984 x 10^{-3} g = (3.984 x 10^{-3} x 6.02 x 10^{23}) ÷ 30

= 8 x 10^{19} molecules of Ethane

44. Fill in the blanks

(a) In a chemical reaction, the sum of the masses of the reactants and products remains unchanged. This is called ————.

(b) A group of atoms carrying a fixed charge on them is called ————.

(c) The formula unit mass of Ca3 (PO4) 2 is ————.

(d) Formula of sodium carbonate is ———— and that of ammonium sulphate is ————.

Soln:

Answers
   a) Law of conservation of mass
   b) Ions
   c) 310

Explanation

3 × atomic mass of Ca+ 2 × atomic mass of phosphorus + 8 × atomic mass of oxygen) = 310

3 × 40 + 2 × 31 + 8 × 16 = 120 + 62 + 128 = 310

   d) Na2 CO3 and (NH4) 2 SO4

45. Complete the following crossword puzzle (Fig. 3.1) by using the name of the chemical elements. Use the data given in Table 3.2.

Across	Down
The element used by Rutherford during his α–scattering experiment	A white lustrous metal used for making ornaments and which tends to get tarnished black in the presence of moist air
An element which forms rust on exposure to moist air	Both brass and bronze are alloys of the element
A very reactive non–metal stored under water	The metal which exists in the liquid state at room temperature
Zinc metal when treated with dilute hydrochloric acid produces a gas of this element which when tested with burning splinter produces a pop sound.	An element with symbol Pb
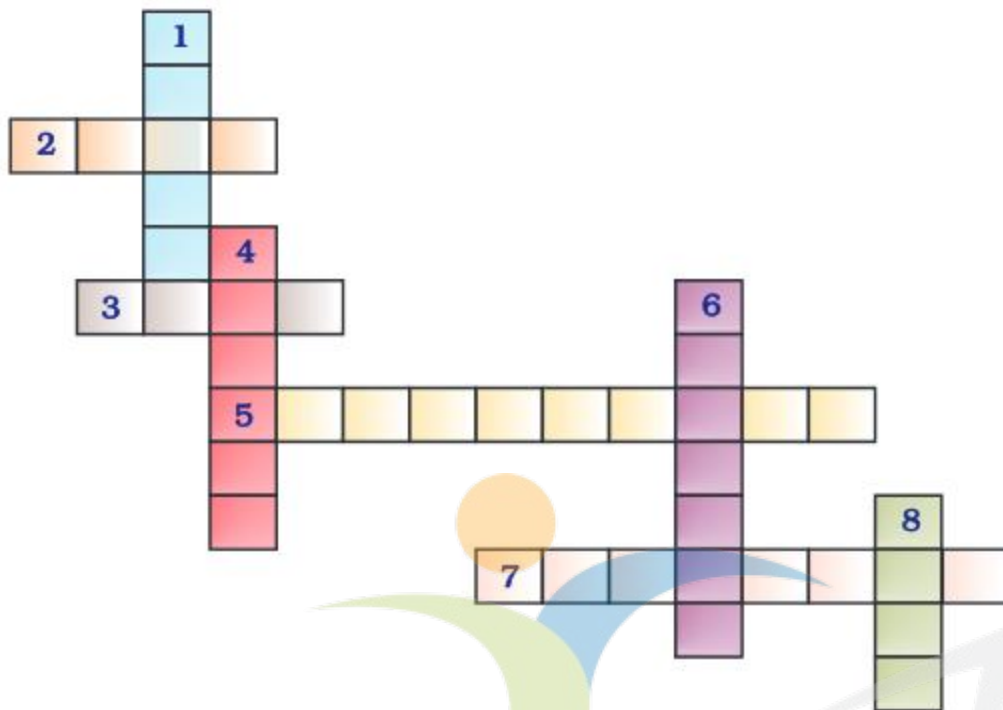
Fig. 3.1

Soln:
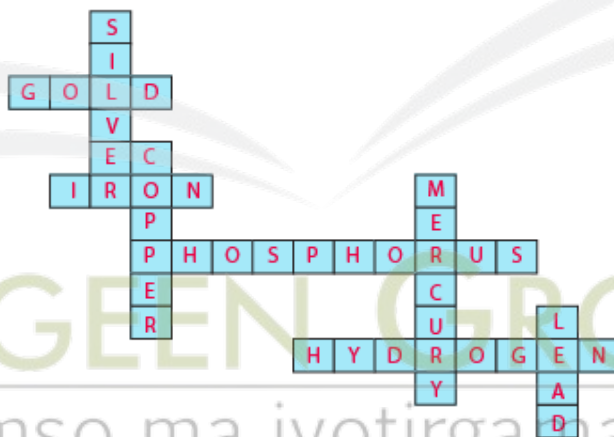
46. (a) In this crossword puzzle (Fig 3.2), names of 11 elements are hidden. Symbols of these are given below. Complete the puzzle. 1. Cl 7. He 2. H 8. F 3. Ar 9. Kr 4. O 10. Rn 5. Xe 11. Ne 6. N
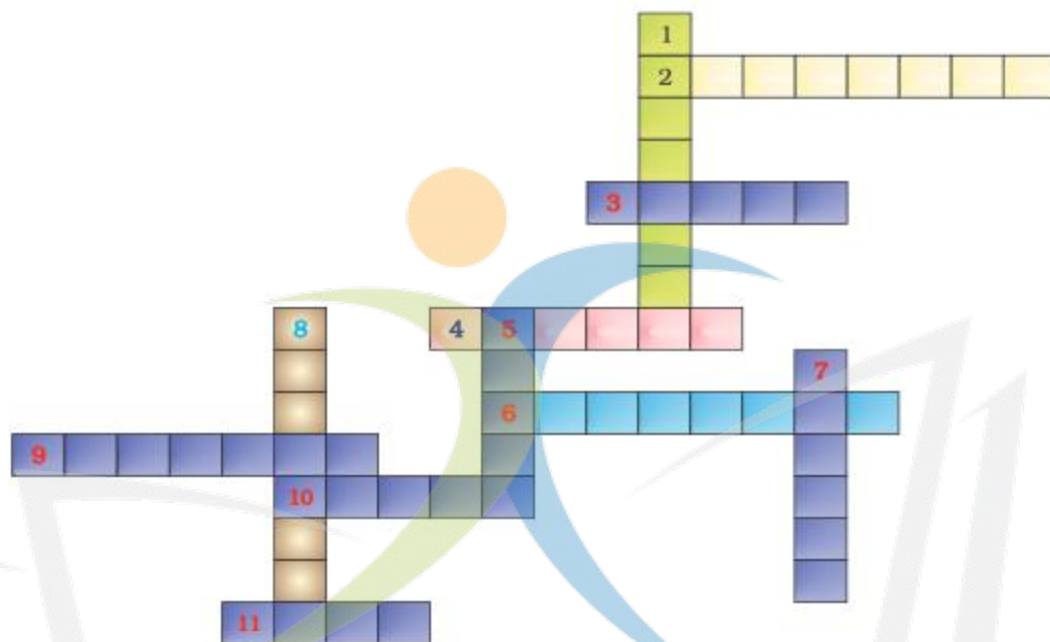
Fig. 3.2

Soln:

(a)

b) Six : Helium (He); Neon (Ne); Argon (Ar); Krypton (Kr); Xenon (Xe); Radon (Rn).

47. Write the formulae for the following and calculate the molecular mass for each one of them.
(a) Caustic potash
(b) Baking powder
(c) Lime stone
(d) Caustic soda
(e) Ethanol
(f) Common salt

Soln:

The formulae for the following and calculate the molecular mass for each one of them.

Sl No	Compound	Formula	Molecular mass
A	Caustic Potash	KOH	39+16+1=56u
B	Baking powder	$NaHCO_3$	23+1+12+3x16+84u
C	Lime stone	$CaCO_3$	40+12+3x16+100u
D	Caustic soda	NaOH	23+16+1+40u
E	Ethanol	C_2H_5OH	2x2+5x1+16+1+46u
F	Common Salt	NaCl	23+35.5=58.5

48. In photosynthesis, 6 molecules of carbon dioxide combine with an equal number of water molecules through a complex series of reactions to give a molecule of glucose having a molecular formula $C_6 H_{12} O_6$. How many grams of water would be required to produce 18 g of glucose? Compute the volume of water so consumed assuming the density of water to be 1 g cm^{-3}.

Soln:

$6CO_2$ + 6 H_2 O Chlorophyll /Sunlight → C_6 H_{12} O_6 + $6O_2$
1 mole of glucose needs 6 moles of water 180 g of glucose needs (6×18) g of water 1 g of glucose will need 108/180 g of water.
18 g of glucose would need (108 /180) × 18 g of water = 10.8 g
Volume of water used = Mass
                              Density
= 10.8 g/ 1g cm-3
=10.8 cm3

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Chapter 3

Atoms and Molecules

</div>

Questions:

Q. 1 In a reaction, 5.3 g of sodium carbonate reacted with 6 g ethanoic acid. The products were 2.2 g of carbon dioxide, o.9 g of water and 8.2 g of sodium ethanoate. Show that these observations are in agreement with the law of conservation of mass.

Sodium Carbonate + Acetic Acid → Sodium Acetate + Carbon Dioxide + Water

Ans.: In the given reaction, sodium carbonate reacts with acetic acid to produce sodium acetate, carbon dioxide, and water.

Sodium Carbonate + Acetic Acid → Sodium Acetate + Carbon Dioxide + Water

Mass of Sodium Carbonate = 5.3 g (Given)

Mass of Acetic Acid = 6 g (Given)

Mass of Sodium Acetate = 8.2 g (Given)

Mass of Carbon Dioxide = 2.2 g (Given)

Mass of Water = 0.9 g (Given)

Now, total mass before the reaction = Mass of (Sodium Carbonate + Acetic Acid) = (5.3 + 6) g

= 11.3 g

And, total mass after the reaction = Mass of (Sodium Acetate + Carbon Dioxide + Water) = (8.2 + 2.2 + 0.9) g

= 11.3 g

∴ Total mass before the reaction = Total mass after the reaction

Hence, the given observations are in agreement with the law of

conservation of mass.

Q.2 Hydrogen and oxygen combine in the ratio of 1 : 8 by mass to from water. What mass of oxygen gas would be required to react completely with 3 g of hydrogen gas?

Ans.: Here we have been given that hydrogen and oxygen always combine in the fixed ratio of 1 : 8 by mass. This means that:

1 g of hydrogen gas requires = 8 h of oxygen gas

So, 3 g of hydrogen gas requires = 8×3 g of oxygen gas

= 24 g of oxygen gas

Thus, 24 grams of oxygen gas would be required to react completely with 3 grams of hydrogen gas.

Q.3 Which postulate of Dalton's atomic theory is the result of the law of conservation of mass?

Ans.: The postulate of Dalton's atomic theory that is the result of the law of conservation of mass are following:

'Atoms are indivisible particles, which cannot be created or destroyed in a chemical reaction.'

'The relative number and kinds of atoms are constant in a given compound.'

Q.4 Which postulate of Dalton's atomic theory can explain the law of definite proportions?

Ans.: The postulate of Dalton's atomic theory that explains the law of definite proportions is 'The relative number and kinds of atoms are constant in a given compound.'

Questions:

Q. 1 Define the atomic mass unit.

Ans.: One atomic mass unit is a mass unit equal to exactly one twelveth (1/12th) the mass of one atom of carbon-12. The relative atomic masses of all elements have been found with respect to an atom of carbon-12.

Q.2 Why is it not possible to see an atom with naked eyes?

Ans.: It is not possible to see an atom with naked eyes because an atom is a very small particle. For example, the radius of a hydrogen atom is 10^{-10} metre.

Questions:

Q. 1 Write down the formulae of:

(i) Sodium oxide

(ii) Aluminum chloride

(iii) Sodium sulphide

(iv) Magnesium hydroxide

Ans.: i) Sodium is an ionic compound made up of sodium ions and oxide ions. The sodium ion has a valency or charge of 1+ where is oxide Ion has a valency or charge of 2-

Symbol – Na   O
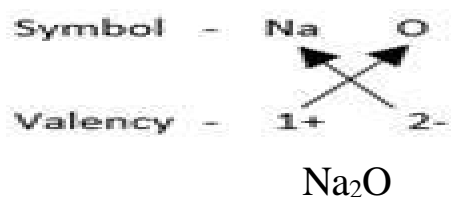
Valency – 1+   2-

Na_2O

Na O1+ 2- (cross over valencies)Formula: Na_2O
Hence, the formula of sodium oxide is Na_2O.
ii) Aluminium chloride is an ionic compound made up of aluminium ions and chloride ions. Aluminium Ion has a valency of 3+ whereas

chloride Ion has a valency of 1-.

AlCl$_3$ Or AlCl$_3$
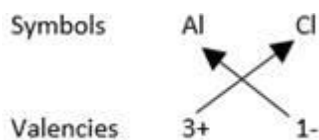
Al Cl3+ 1- (cross over valencies)Formula: AlCl$_3$
Hence, the formula of aluminium chloride is AlCl$_3$.

iii) Sodium sulphide ionic compound made up of sodium ions and sulphide ions. Sodium Ion has a valency of 1+ ion has a valency of 2-
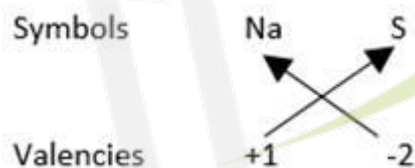
Na S1+ 2- (cross over valencies)Formula: Na$_2$S
Hence, the formula of sodium sulphide is Na$_2$S.
iv) Magnesium hydroxide is an ionic compound made up of magnesium and Hydroxide ions. Magnesium iron has a valency of 2+ and Hydroxide has a valency of 1-
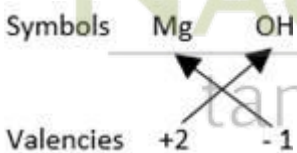
Mg OH2+ 1- (cross over valencies)Formula: Mg(OH)$_2$
Hence, the formula of magnesium hydroxide is Mg(OH)$_2$.

Q. 2 Write down the names of compounds represented by the following formulae:

(i) Al$_2$(SO$_4$)3
(ii) CaCl$_2$
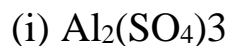
(iii) K_2SO_4

(iv) KNO_3

(v) $CaCO_3$

Ans.:

(i) The name of this compound is Aluminium sulphate.

(ii) The name of this compound is Calcium chloride.

(iii) The name of this compound is Potassium sulphate.

(iv) The name of this compound is potassium nitrate.

(v) The name of this compound is Calcium carbonate.

Q.3 What is meant by the term chemical formula?

Ans.: The chemical formula of a compound is a symbolic representation of its composition. The combining power or combining capacity of an element is known as its valency. Valency can be used to find out how the atoms of an element will combine with the atom(s) of another element to form a chemi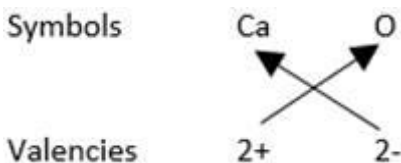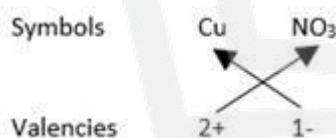cal compound. Some elements show more than one valency. Then we must crossover the valencies of the combining atoms. The positive and negative charges must balance each other and the overall structure must be neutral.

Q.4 How many atoms are present in a:

(i) H_2S molecule, and

(ii) PO_4^{3-} ion?

Ans.:

(i) There are three atoms in a H_2S molecule. Two hydrogen atoms and one sulphur.

(ii) There are five atoms present in a PO_4^{3-} ion. One phosphorus atom and four oxide ions.

Questions:

Q. 1 Calculate the molecular masses of H_2, O_2, Cl_2, CO_2, CH_4, C_2H_6, C_2H_4, NH_3, CH_3OH (Atomic masses: H = 1; O = 16; Cl = 35.5; C = 12; N = 14)

Ans.: The molecular mass of a substance is the sum of the atomic masses of all the atoms in a molecule of the substance. It is therefore the relative mass of a molecule expressed in atomic mass units (u).

(i) Atomic mass of Hydrogen = 1 u.

Molecular mass of H_2 = Mass of 2H atoms = 2 x 1 = 2 u

(ii) Atomic mass of Oxygen = 16 u

Molecular mass of O_2 = Mass of 2 'O' atoms = 2 X 16 = 32 u

(iii) Atomic mass of Cl = 35.5 u

Molecular mass of Cl_2 = Mass of 2Cl atoms = 2 X 35.5 = 71 u

(iv) In this molecule, there is one carbon atom and two oxygen atoms.

Atomic mass of Carbon = 12 u

Atomic mass of Oxygen = 16 u

Molecular mass of CO_2 = Mass of C atom + Mass of 2 'O' atoms

= 12 + 2 X 16 = 12 + 32 = 44 u

(v) Methane molecule has one carbon atom and four hydrogen atoms.

Atomic mass of Carbon = 12 u, Atomic mass of Hydrogen = 1 u

Molecular mass of CH_4 = Mass of C atom + Mass of 4H atoms

= 12 + 4 X 1 = 12 + 4 = 16 u

(vi) C_2H_6 molecule has two carbon atoms and six hydrogen atoms.

Atomic mass of Carbon = 12 u, Atomic mass of Hydrogen = 1 u

Molecular mass of C_2H_6 =Mass of 2C atoms + Mass of 6H atoms

= 2 X 12 + 6 X 1 = 24 + 6 = 30 u

(vii) C_2H_4 molecule has two carbon atoms and four hydrogen atoms.

C_2H_6 molecule has two carbon atoms and four hydrogen atoms.

Molecular mass of C_2H_4 = Mass of 2C atoms + Mass of 4 H atoms

= 2 X 12 + 4 X 1 = 24 + 4 = 28 u

(viii) NH_3 molecule has one nitrogen atom and three hydrogen atoms.

Atomic mass of Nitrogen = 14 , Atomic mass of hydrogen = 1 u

Molecular mass of NH_3 = Mass of N atom + Mass of 3H atoms

= 14 + 3 X 1 = 14 + 3 = 17 u

(ix) CH_3OH molecule has one carbon atom, four hydrogen atoms and one oxygen atom.

Atomic mass of carbon = n 12 u, Atomic mass of hydrogen = 1 u and Atomic mass of oxygen = 12 u.

Molecular mass of CH_3OH = Mass of C + Mass of 4 H + Mass of 0

= 12 + 4 X 1 + 16 = 12 + 4 + 16 = 32 u

Q. 2 Calculate the formula unit masses of ZnO, Na_2O, K_2CO_3

 (Given: Atomic masses of Zn = 65 u; Na = 23 u; K = 39 u; C = 12u and O = 16 u)

Ans.: (i) Formula mass of ZnO = Mass of Zn atom + Mass of 0 atom

= 65 + 16 = 81 u

(ii) Formula mass of Na_2O = Mass of 2Na atoms + Mass of 0

= 2 X 23 + 16 = 46 + 16 = 62 u

(iii) Formula mass of K_2CO_3 = Mass of two potassium atoms + one carbon atom + three oxygen atoms

= 2 X39 + 12+ 3 X16 = 78+ 12+ 48 = 138 u

Exercise

Questions:

Q. 1 A 0.24 g sample of compound of oxygen and boron was found by analysis to contain 0.096 g of boron and 0.144 g of oxygen. Calculate the percentage composition of the compound by weight.

Ans.: (i) Mass of boron in compound = 0.096 g

And, Mass of compound = 0.24 g

So, Percentage of Boron $= \dfrac{Mass\ of\ Boron\ in\ Compound}{Mass\ of\ compound} \times 100$

$= \dfrac{0.096}{0.24} \times 100$

= 40%   …….(i)

(ii) Mass of oxygen in compound = 0.144 g

And, Mass of compound = 0.24 g

So, Percentage of oxygen $= \dfrac{Mass\ of\ Boron\ in\ Compound}{Mass\ of\ compound} \times 100$

$= \dfrac{0.144}{0.24} \times 100$

= 60%   …….(ii)

Thus, the percentage composition of the compound is: Boron = 40%; Oxygen = 60%

Q. 2 When 3.0 g of carbon is burnt in 8.00 g of oxygen, 11.00 g of carbon dioxide is produced. What mass of carbon dioxide will be formed when 3.00 g of carbon is burnt in 50.00 g of oxygen? Which law of chemical combination will govern your answer?

Ans.: Answer will be governed by the law of constant proportions which states that the mass of reactant must be equal to the mass of the product formed during a reaction

Now, since carbon and oxygen combine in the fixed proportion of 3 : 8 by mass to produce 11 g of carbon dioxide,

$$C + O_2 = CO_2$$
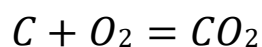
3 + 8 = 11 (by ratio proportion)According to the question, the equation formed will be:-

$$C + 2O_2 = CO_2 + O_2$$
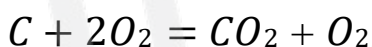
3 +50 = 11 + 42 53 = 53Therefore, the same mass of carbon dioxide (11 g) will be obtained even if we burn 3 g of carbon in 50 g of oxygen. The extra oxygen (50 – 8 = 42 g oxygen) will remain unchanged.

Q.3 What are polyatomic ions? Give examples.

Ans.: Polyatomic ions is the group of atom carrying positive or negative charge. For example,ammonium ion, NH^+, is a polyatomic ion which is made up of two types of atoms, nitrogen (N) and hydrogen (H) joined together.

Similarly,carbonate - CO_3^{2-} , sulphate -SO_4^{2-}, nitrate - NO_3^- and hydroxide ions OH⁻ are all polyatomic ions.

Q.4 Write the chemical formulae of the following:

(a) Magnesium chloride

(b) Calcium oxide

(c) Copper Nitrate

(d) Aluminium chloride

(e) Calcium carbonate

Ans.: (a) The chemical formula of a compound is a symbolic representation of its composition. The combining power or combining capacity of an element is known as its valency. Valency can be used to find out how the atoms of an element will combine with the atom(s) of another element to form a chemical compound. Some elements show more than one valency.

While writing the chemical formulae for compounds, we write the constituent elements or their symbols and their valencies as shown below. Then we must crossover the valencies of the combining atoms. The positive and negative charges must balance each other and the overall structure must be neutral.
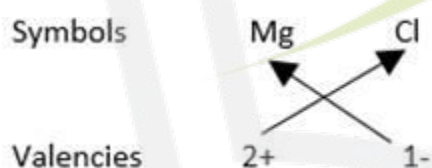
In magnesium chloride, there will be two chloride ions per one magnesium ion. Thus, the formula or magnesium chloride is $MgCl_2$.

(b) The chemical formula of a compound is a symbolic representation of its composition. The combining power or combining capacity of an element is known as its valency. Valency can be used to find out how the atoms of an element will combine with the atom(s) of another element to form a chemical compound. Some elements show more than one valency.

While writing the chemical formulae for compounds, we write the constituent elements or their symbols and their valencies as shown below. Then we must crossover the valencies of the combining atoms. The positive and negative charges must balance each other and the overall structure must be neutral.

Symbols Ca O

Valencies 2+ 2-

Thus, the formula of Calcium Oxide is CaO.

(c) The chemical formula of a compound is a symbolic representation of its composition. The combining power or combining capacity of an element is known as its valency. Valency can be used to find out how the atoms of an element will combine with the atom(s) of another element to form a chemical compound. Some elements show more than one valency.

While writing the chemical formulae for compounds, we write the constituent elements or their symbols and their valencies as shown below. Then we must crossover the valencies of the combining atoms. The positive and negative charges must balance each other and the overall structure must be neutral.

Symbols Cu NO_3

Valencies 2+ 1-

Thus, the formula or copper nitrate is $Cu(NO_3)_2$

(d) The chemical formula of a compound is a symbolic representation of its composition. The combining power or combining capacity of an element is known as its valency. Valency can be used to find out how the atoms of an element will combine with the atom(s) of another element to form a chemical compound. Some elements show more than one valency.

While writing the chemical formulae for compounds, we write the constituent elements or their symbols and their valencies as shown below. Then we must crossover the valencies of the combining atoms. The positive and negative charges must balance each other and the overall structure must be neutral.

Symbols   Al   Cl

Valencies   3+   1-

Al_1Cl_3 or $AlCl_3$
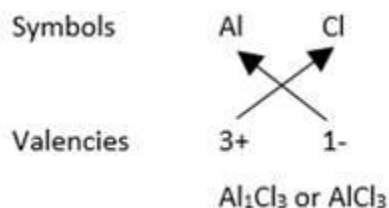
In Aluminium Chloride, there are three chloride ions per one aluminium ion. Thus, the Aluminium chloride is $AlCl_3$.

(e) The chemical formula of a compound is a symbolic representation of its composition. The combining power or combining capacity of an element is known as its valency. Valency can be used to find out how the atoms of an element will combine with the atom(s) of another element to form a chemical compound. Some elements show more than one valency.

While writing the chemical formulae for compounds, we write the constituent elements or their symbols and their valencies as shown below. Then we must crossover the valencies of the combining atoms. The positive and negative charges must balance each other and the overall structure must be neutral.

Symbols   Ca CO_3

Valencies   2+   - 2
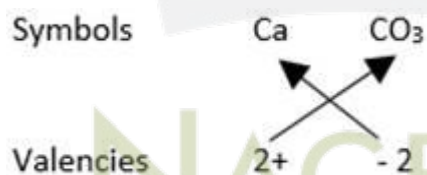
Thus, the formula or calcium carbonate is $CaCO_3$.

Q.5 Give the names of the elements present in the following compounds:

(a) Quick lime

(b) Hydrogen bromide

(c) Baking soda

(d) Potassium sulphate

Ans.:

(a) Calcium oxide, CaO is also known as quick lime. The elements present in quick lime are: Calcium (Ca) and Oxygen (O).

(b) The chemical formula of hydrogen bromide is HBr. The elements present in hydrogen bromide are: Hydrogen (H) and Bromine (Br).

(c) Baking soda is sodium hydrogen carbonate, and its chemical formula is $NaHCO_3$. The elements present in baking soda are: Sodium (Na), Hydrogen (H), Carbon (C) and Oxygen (O).

(d) The chemical formula of potassium sulphate is K_2SO_4. The elements present in potassium sulphate are: Potassium (K), Sulphur (S) and Oxygen (O).

Q. 6 Calculate the molar masses of the following substances:

(a) Ethyne, C_2H_2

(b) Sulphur molecule, S_8

(c) Phosphorus molecule, P_4

(d) Hydrochloric acid, HCl

(e) Nitric acid, HNO_3

Ans: The molar masses of all these substances will be equal to the respective molecular masses expressed in g/mol. Now:\(a) Molar mass of ethyne, C_2H_2 = Mass of C × 2 + Mass of H × 2

$= 12 \times 2 + 1 \times 2$

$= 24 + 2$

$= 26$ g/mol

(b) Molar mass of sulphur molecule, S_8 = Mass of S × 8

$= 32 \times 8$

$= 256$ g/mol

(c) Molar mass of phosphorus molecule, P_4 = Mass of P × 4

= 31 × 4

= 124 g/mol

(d) Molar mass of hydrochloric acid, HCl = Mass of H + Mass of Cl

= 1 + 35.5

= 36.5 g/mol

(e) Molar mass of nitric acid, HNO_3

= Mass of H + Mass of N + Mass of O × 3

= 1 + 14 + 16 × 3

= 15 + 48

= 63 g/mol
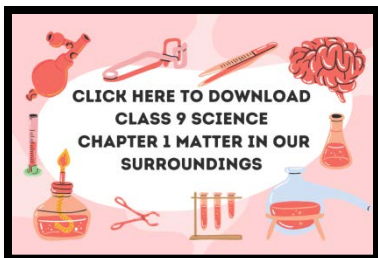
03 ATOMS AND MOLECULES

MIND MAP

Combine in ratios of whole numbers relative number is constant

Building blocks of matter; neither be created nor be destroyed

atomic radius
$$\left\{ \text{measured in Å, pm or nm} \right\}$$

atomic mass
$$\left\{ \begin{array}{l} \text{amu} = 6 \times 10^{-24}\text{g} \\ \text{carbon isotope } \frac{1}{12} \text{ of } {}_6\text{C}^{12} \end{array} \right\}$$

Element has identical in mass & chemical proportion

Quantity characterised by number of molecules

Properties

Proust law - In chemical substance elements always present in definite proportion by mass

Mole concept substance

e.g. mass of hydrogen is always 1 : 8 in
$$H_2O$$

Mass

Constant Proportions

Sum of atomic masses of all atoms
$$HNO_3 \; 1 + 14 + (16 \times 3) = 62$$

Atoms and Molecules

Laws

Lavoisier & Joseph Proust

Molecules symbols
$$1 \times 23 + 1 \times 35.5 = 58.5u \; NaCl$$

Conservation of mass It states that the mass can be neither created be nor destroyed

Chemical Formula

Ions charged species

Molecules

Two or more atoms chemically bonded
Atoms of same / different elements form molecules

HCl^- symbolic representatio

Valency rules

H   Cl
1   1
or HCl

Cl^- -ve (anion acidic radical)

Na^+ +ve (cation base radical)

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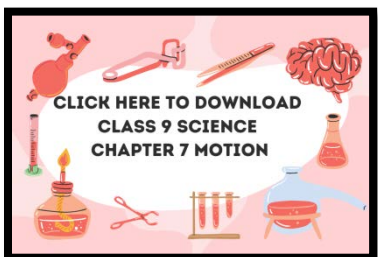
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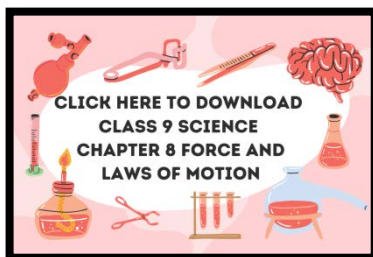
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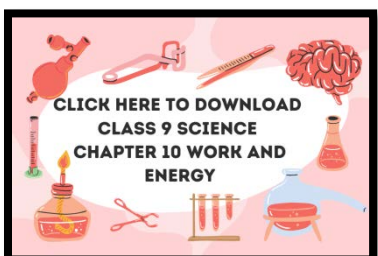
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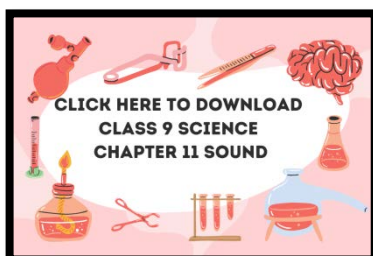
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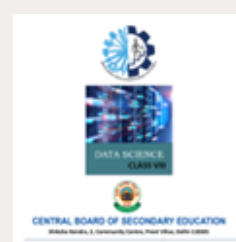
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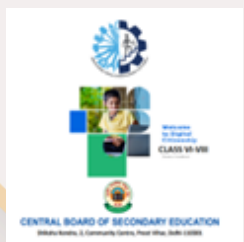
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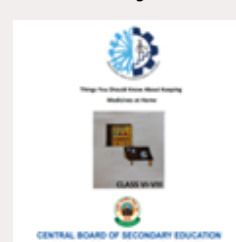
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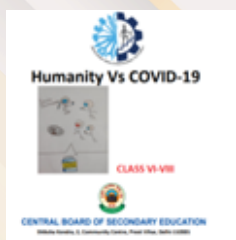
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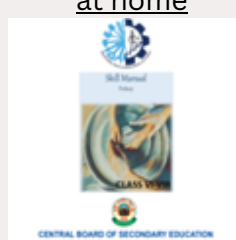
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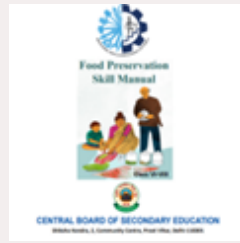
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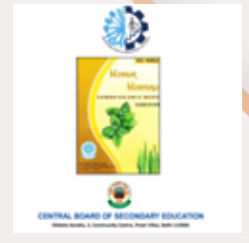
Herbal Heritage

Khadi
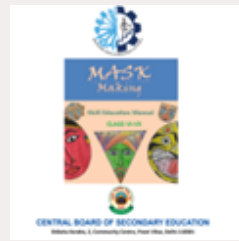
Mask Making

Mass Media
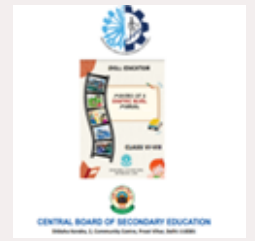
Making of a Graphic Novel
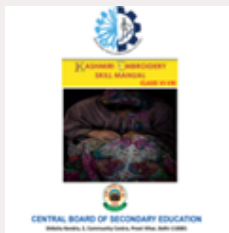
Kashmiri Embroidery

Embroidery

Rockets

Satellites
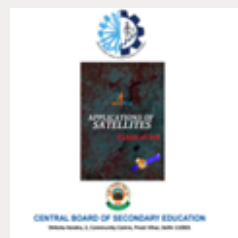
Application of Satellites
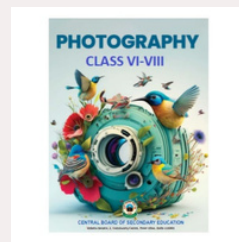
Photography

SKILL SUBJECTS AT SECONDARY LEVEL (CLASSES IX – X)

Retail
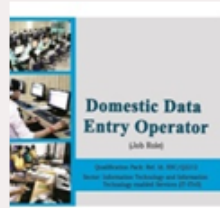
Information Technology

Security

Automotive

Introduction To Financial Markets
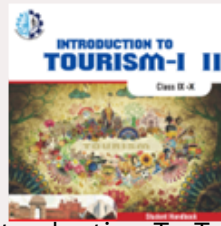
Introduction To Tourism

Beauty & Wellness

Agriculture

Food Production

Front Office Operations

Banking & Insurance

Marketing & Sales

Health Care

Apparel

Multi Media

Multi Skill Foundation Course

Artificial Intelligence

Physical Activity Trainer

Data Science

Electronics & Hardware (NEW)

Foundation Skills For Sciences (Pharmaceutical & Biotechnology)(NEW)

Design Thinking & Innovation (NEW)

SKILL SUBJECTS AT SR. SEC. LEVEL (CLASSES XI – XII)

Retail
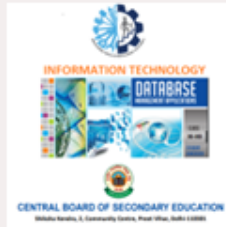
InformationTechnology

Web Application

Automotive

Financial Markets Management

Tourism

Beauty & Wellness

Agriculture

Food Production

Front Office Operations

Banking

Marketing

Health Care

Insurance
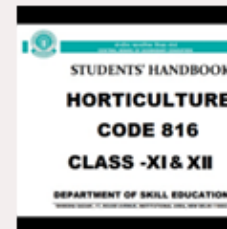
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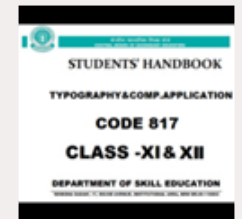
Typography & Comp. Application

Geospatial Technology
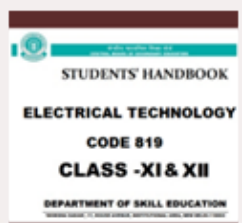
Electrical Technology

Electronic Technology
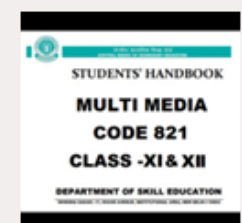
Multi-Media

Taxation
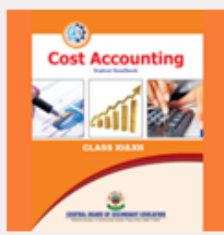
Cost Accounting
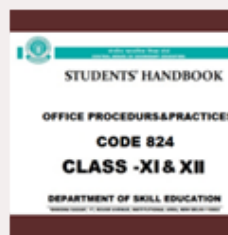
Office Procedures & Practices
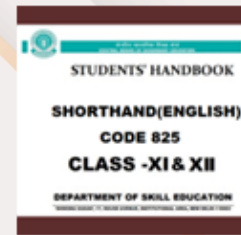
Shorthand (English)
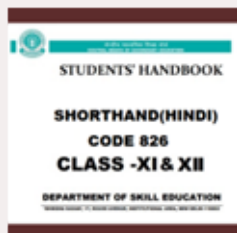
Shorthand (Hindi)
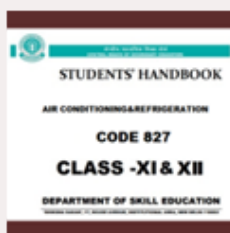
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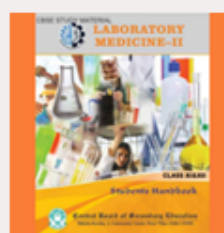
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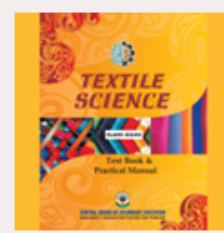
Textile Design
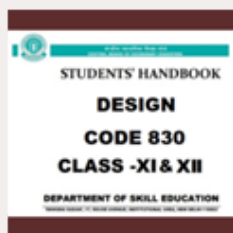
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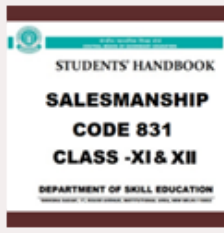
Salesmanship
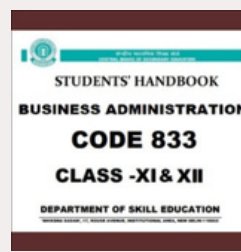
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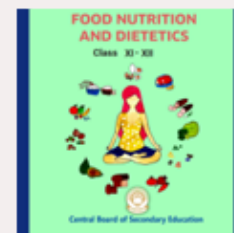
Food Nutrition & Dietetics
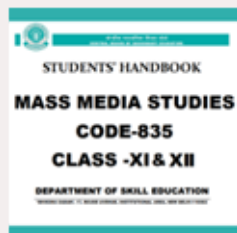
Mass Media Studies

Library & Information Science
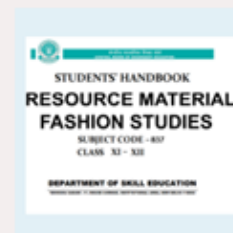
Fashion Studies
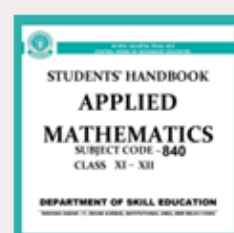
Applied Mathematics

Yoga

Early Childhood Care & Education
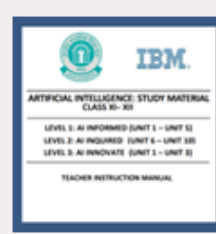
Artificial Intelligence

Data Science

Physical Activity Trainer(new)
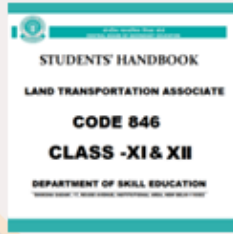
Land Transportation Associate (NEW)

Electronics & Hardware (NEW)

Design Thinking & Innovation (NEW)

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SOE · Click Here to Join
Hindi-A

SOE · Click Here to Join
Hindi-B

SOE · Click Here to Join
IT Code-402

SOE · Click Here to Join
IT

SOE · Click Here to Join
Artifical intelligence

Senior Secondary Groups XI & XII

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SOE · Click Here to Join
Chemistry

SOE · Click Here to Join
English

SOE · Click Here to Join
Mathematics

SOE · Click Here to Join
Biology

SOE · Click Here to Join
Accountancy

SOE · Click Here to Join
Economics

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BST

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History

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Hindi Core	**Home Science**	**Sanskrit**
Psychology	**Political Science**	**Painting**
Vocal Music	**Comp. Science**	**IP**
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Entrepreneurship	**French**	**IIT/NEET**
	Artifical intelligence	**CUET**

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Class 9	**Class 10**	**Class 11 (Sci)**
Class 11 (Com)	**Class 11 (Hum)**	**Class 12 (Sci)**
Class 12 (Com)	**Class 12 (Hum)**	

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